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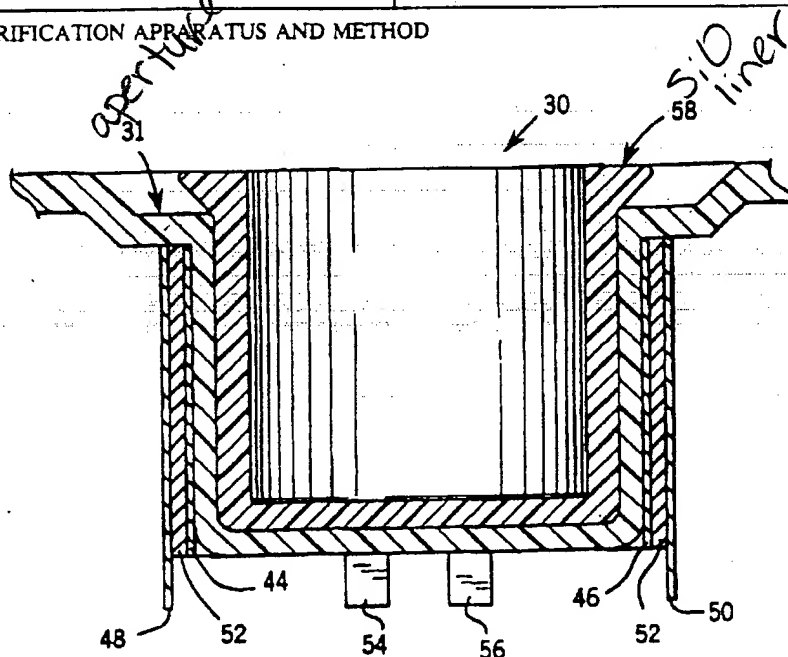
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(54) Title: VOLUME VERIFICATION APPARATUS AND METHOD



(57) Abstract

Embodiments disclosed herein provide apparatus and methods for verifying a volume of fluid. According to one embodiment, an apparatus includes a receptacle for containing fluid, a first conductor operatively associated with the receptacle and a second conductor operatively associated with the receptacle offset from the first conductor. A source of a first electrical signal is electrically connected with the first conductor. A monitor is electrically connected with the second conductor for detecting a second electrical signal created in the second conductor. In another embodiment, a method includes positioning a receptacle adjacent a fluid dispense nozzle such that fluid dispensed from the nozzle enters the receptacle. A first electrical signal is applied to a first conductor operatively connected with the receptacle. A second electrical signal created in a second conductor operatively connected with the receptacle responsive to the first electrical signal is monitored.

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VOLUME VERIFICATION APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

Embodiments of the present invention generally relate to an apparatus and a method for checking or verifying a volume of a fluid. More specifically, the embodiments relate to an apparatus and a method for verifying fluid volume for use in an automated instrument.

Automated instruments are available to perform a number of tasks. One such automated instrument is an analytical instrument. An analytical instrument can perform tests, such as medical diagnostic tests, on a sample. For example, such tests may identify the AIDS virus in a blood sample or other item of interest in a biological sample.

To perform such tests, an analytical instrument may mix the biological sample with a substance, such as a reagent and the like. In some embodiments, these reagents may be fluids. The fluids may be supplied to the biological sample within the medical instrument by a fluid system. The fluid system may include a source of fluid, a pump, a dispense nozzle and a conduit fluidly connecting those elements. The source of fluid may be a container and the like. The pump moves fluid from the

container toward the dispense nozzle through the conduit. The sample, which may be held in a suitable container, is positioned adjacent the dispense nozzle. When the pump is operated, fluid from the container leaves the nozzle and enters the sample
5 container. Movement of the fluid into the container, if desired, can cause the fluid and the sample to mix.

Illustrating further by example, a given instrument may perform a blood analysis. The instrument adds a predetermined volume of a fluid to a predetermined volume of a blood sample.
10 The fluid reacts with the blood sample. Because of the reaction between the sample and the fluid, an electromagnetic or chemical optical signal or light is sent from the mixture of sample and fluid. A detector in the instrument sees or reads the light sent from the mixture. Appropriate elements of the instrument,
15 such as a computer and the like, interpret the information obtained by the detector and provide an operator with information about the blood sample.

In order for this instrument to perform as intended and to give accurate results, it is desirable that a specific,
20 predetermined amount or volume of fluid be mixed with the sample. If too much or too little fluid were added to the sample, the light sent from the mixture may be different from the proper light sent from the mixture when the predetermined volume of fluid is added. The different light sent from the
25 mixture is interpreted by the computer in the same way as the proper light. Therefore, the computer may give inaccurate information to the operator of the instrument.

The possibility of inaccurate information being given by an instrument is a concern. For example, the test performed may be
30 to see if a unit of blood were infected with the AIDS virus. Assuming that the blood is infected with the AIDS virus, adding too little or too much fluid to the blood sample may result in the instrument telling the operator that the unit of blood is not infected with the AIDS virus. Accordingly, it can be
35 appreciated that it is desirable to have an apparatus

connectable with the instrument for checking elements of a fluid system and for verifying that the proper, predetermined amount of fluid has left the dispense nozzle and entered the container during operation of the analytical instrument.

5

SUMMARY OF THE INVENTION

Embodiments disclosed herein provide apparatus and methods for verifying a volume of fluid. According to one embodiment, an apparatus includes a receptacle for containing fluid, a first conductor operatively associated with the receptacle and a second conductor operatively associated with the receptacle offset from the first conductor. A source of a first electrical signal is electrically connected with the first conductor. A monitor is electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

In another embodiment, a method includes positioning a receptacle adjacent a fluid dispense nozzle such that fluid dispensed from the nozzle enters the receptacle. A first electrical signal is applied to a first conductor operatively connected with the receptacle. A second electrical signal created in a second conductor operatively connected with the receptacle responsive to the first electrical signal is monitored.

In a further embodiment, a method comprises placing a volume of fluid within a receptacle. A first conductor is positioned adjacent the receptacle such that the first conductor does not contact the volume of fluid. A second conductor is positioned adjacent the receptacle such that the second conductor does not contact the volume of fluid or the first conductor. A first electrical signal is applied to the first conductor. A second electrical signal generated in the second

conductor responsive to the first electrical signal is monitored to verify the volume of the fluid in the receptacle.

In an additional embodiment, an apparatus for verifying a volume of fluid comprises a receptacle for containing fluid. A first conductor is operatively associated with the receptacle such that the first conductor does not contact the volume of the fluid. A second conductor is operatively associated with the receptacle offset from the first conductor such that the first conductor does not contact the volume of the fluid. A source of a first electrical signal is electrically connected with the first conductor. A monitor is electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

15

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram view of a volume verification apparatus disclosed herein;

20 Fig. 2 is an enlarged plan view of a portion of the apparatus of Fig. 1;

Fig. 3 is a sectional view, along line 3-3 of Fig. 2;

Fig. 4 is an enlarged sectional view of a portion of the apparatus shown in Figs. 2 and 3;

25 Fig. 5 is a plan view of an element of the apparatus shown in Fig. 4;

Fig. 6 is a side elevational view of a portion of the element shown in Fig. 5;

30 Fig. 7 is a block schematic diagram of a portion of the apparatus of Fig. 1;

Fig. 8 is a generic block diagram of a portion of the apparatus of Fig. 1;

Figs. 9A and 9B are schematic diagrams of elements of the portion illustrated in Fig. 7;

Fig. 10 is a schematic diagram of elements of the portion illustrated in Fig. 7;

Fig. 11 is a schematic diagram of elements of the portion illustrated in Fig. 7; and

5 Fig. 12 is a schematic diagram of elements of the portion illustrated in Fig. 7.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

10

The embodiments disclosed herein relate to an apparatus and a method for verifying a volume of fluid. The embodiments may be used with any desired fluid with suitable modifications to provide compatibility with the desired fluid, e.g. non-
15 reactivity. The embodiments may be utilized in any suitable employment. For the sake of clarity, the embodiments are discussed with respect to their employment with an analytical instrument. The analytical instrument may be substantially similar to those disclosed in U.S. Patent No.'s 5,006,309,
20 5,015,157, 5,089,424, 5,120,199, Des. 332,834, 5,185,264, 5,198,368, 5,232,669, 5,244,630, 5,246,354, 5,283,178, 5,299,446 and 5,151,518. Those patents are assigned to the assignee of the present invention and the disclosures thereof are incorporated herein by reference. It is to be noted that the
25 embodiments disclosed herein may be modified in any desirable fashion to produce still other embodiments. For instance, steps of one method may be combined, in any desired order, with steps of another method to arrive at yet another method.

Fig. 1 illustrates a volume verification apparatus 10 which
30 verifies a volume of a fluid, such as a reagent, a sample and the like. It is to be noted that the apparatus 10 verifies fluid volume without requiring an electrode or conductor to come into physical contact with the volume of fluid being verified. This property of the apparatus 10 is advantageous, i.e. to
35 reduce fluid carryover and the like.

The apparatus 10 generally comprises a sensor unit 12, a feedback mechanism 14 and a source 16 of electrical energy. The sensor unit 12 is operatively connectable with an analytical instrument 18 for verifying a fluid volume associated with the analytical instrument 18. The sensor unit 12 is electrically connected with the feedback mechanism 14 by conductor 20. Conductor 22 electrically connects the feedback mechanism 14 with the source 16 of electrical energy such that the feedback mechanism 14 and the sensor unit 12 are supplied with electrical energy. In some embodiments, a conductor 24 is provided that electrically connects the feedback mechanism 14 to a computer 26. In other embodiments, a conductor 28 is provided which electrically connects the computer 26, in parallel, with the analytical instrument 18. In still further embodiments, the conductor 28 may directly electrically connect the feedback mechanism 14 with the analytical instrument 18, which may integrate the computer 26.

The sensor unit 12 includes at least one receptacle 30 for containing a volume of fluid to be verified. The sensor unit 12 may have a configuration which corresponds to a complementary configuration on the analytical instrument 18 to provide compatibility. The feedback mechanism 14 includes structures, such as a display 32 and the like, for providing an operator with feedback indicative of the volume of fluid to be verified. The feedback mechanism may also be provided with a switch 34 for selecting electrical connection between the sensor unit 12 and the source 16 of electrical energy. The computer 26 includes memory containing and running appropriate routines to control operation of the apparatus 10 and to utilize the feedback provided by the feedback mechanism 14.

Fig. 2 illustrates the sensor unit 12 in more detail. The sensor unit 12 contains at least one receptacle 30 for containing a volume of fluid to be verified and a circuit board 35. The receptacle 30 is defined by an aperture 31 on the sensor unit 12. The number of receptacles 30, as well as their

disposition is dependent upon the construction of relevant portions of the analytical instrument 18. The circuit board 35 is supported in a housing 36 by suitable structures. The circuit board 35 may be accessed from an exterior of the housing 36 through panel 38 which may be removable from the housing 36. The housing 36 also comprises a port 40 for accepting the conductor 20 thereby permitting electrical connection between the circuit board 35 and the feedback mechanism 14. In one embodiment, the housing 36 is substantially rectangular having a length of about 6.5 inches, a width of about 3 inches and a height of about 0.9 inches. In the illustrated embodiment, six receptacles 30 are formed in the housing 36, however, other numbers are also possible.

An exemplary receptacle 30, illustrated in Fig. 4, comprises a first conductor 44 and a second conductor 46 operatively associated with the aperture 31. In a exemplary embodiment, the first conductor 44 may be a transmitter while the second conductor 46 may be a receiver. The first conductor 44 and the second conductor 46 include, respectively, contacts 54 and 56 that permit electrical connections with the first conductor 44 and the second conductor 46.

The contacts 54 and 56 allow an electromagnetic signal to be sent to or from the conductors 44 and 46, respectively. The first conductor 44 and the second conductor 46 are electromagnetically coupled such that electromagnetic signal transmission between the first conductor 44 and the second conductor 46 depends upon a substance, such as a volume of fluid and the like, operatively disposed between the first conductor 44 and the second conductor 46. By appropriately consulting electromagnetic signal transmission between the conductors 44 and 46, an operator can determine or verify a volume of fluid contained within the receptacle 30, i.e. the volume of fluid dispensed by the analytical instrument 18.

An exemplary construction of the conductors 44 and 46 is illustrated in Figs. 5 and 6. The conductors 44 and 46 are

formed from pieces or sheets of a suitable metal, such as copper and the like. The conductors 44 and 46 are formed or curved in a substantially semicylindrical shape. In one embodiment, the conductors 44 and 46 define a diameter of about 0.5 inches and have a height of about 0.5 inches and a thickness of about 0.01 inches. The contacts 54 and 56 depend from the substantially semicylindrical bodies of the conductors 44 and 46. The contacts 54 and 56 are about 0.08 inches wide and about 0.125 inches long. As shown in Fig. 5, the first conductor 44 is offset from the second conductor 46 by a gap 60 measuring about 0.05 inches.

Some embodiments include a third conductor 48 and a fourth conductor 50, operatively associated with the first conductor 44 and the second conductor 46, respectively, to reduce electromagnetic interference received by the first conductor 44 and the second conductor 46. In these embodiments, an insulator 52 may be disposed electrically between the first conductor 44 and the third conductor 48 and electrically between the second conductor 46 and the fourth conductor 50. In some embodiments, the third conductor 48 and the fourth conductor 50 may be integrated as a single conductor.

The aperture 31 associated with a particular receptacle 30 provides support for the conductors 44 through 50 and the insulator 52. In some embodiments, the conductors 44 through 50 and the insulator 52 may be removed from the associated aperture 31 for cleaning, replacement, etc.

In still further embodiments, a liner 58 may be disposed within the aperture 31 at a side thereof opposite to the side thereof adjacent the conductors 44 and 46. The liner 58 may be made from a material that is compatible, e.g. non-reactive, with the fluid, a volume of which is to be verified by the apparatus 10. In some embodiments, the liner 58 may be removable for replacement, cleaning, etc. In other embodiments, the liner 58 may be a coating or other treatment applied to the aperture 31.
In still other embodiments, the liner 58 may be provided on an

inner surface of a removable insert which is removably connectable with the aperture 31. The insert may be made of a suitable, non-electrically conducting polymer, such as Monsanto Lustran 248.

5 In one embodiment, the liner 58 comprises a low friction substance, such as a silicone and the like, to reduce a meniscus curvature formed by a fluid disposed within the liner 58 and thereby within the receptacle 30. In an exemplary embodiment, the liner 58 comprises a polymeric coating, such as dimethyl-
10 hydroxyl-alkylene-oxide-methyl-siloxane (United Chemical Technologies #PS835, Bristol, PA). If a removable insert were used, then, in one embodiment, at least one insert is placed in a mixture of silicone or about 2.0 grams of dimethyl-hydroxyl-alkylene-oxide-methyl-siloxane and about 98 grams of
15 trichlorotrifluoroethane (Baxter Scientific Products MS-80902, Sunnyvale, CA). The insert is removed from the mixture and drained. The insert is dried at about 80 degrees Celsius for about 2 hours. The insert is rinsed. Then, the insert is placed in a bath of distilled water for about 5 minutes and the
20 insert is drained. The insert is dried again at about 80 degrees Celsius for about 2 hours. The liner 58 and/or the insert is substantially cylindrical, having an open end and a closed end, with an inner diameter of about 0.51 inches, an outer diameter of about 0.59 inches and a height of about 0.56
25 inches.

An exemplary embodiment of electronic structure or circuit 61 associated with the sensor unit 12 is illustrated generally in Fig. 7, with detailed electronic schematic diagrams presented in Figs. 8 through 12. An oscillator 62 generates a periodic
30 electrical signal substantially in the radio frequency range. In an exemplary embodiment, the oscillator 62 generates a substantially square wave of about 1.58 Volts peak-to-peak with an approximate 3.6 Volts (DC) offset at a frequency of about 100 kHz. An exemplary embodiment of the oscillator 62 is shown in
35 Figs. 9A and 9B.

The oscillator 62 is electrically connected to a filter 64 (bandpass) with a passband of about 60 kHz centered at about 100 kHz. The filter 64 converts the periodic signal from the oscillator 62 to an electrical signal of substantially similar frequency but of approximately sinusoidal form. The construction of the filter 64 is shown in Figs. 9A and 9B. The filter 64 is electrically connected to an amplifier 66, also shown in detail in Figs. 9A and 9B, which increases an amplitude of the electrical signal by a factor of about 7.5, yielding an approximately 11.0 Volt peak-to-peak (AC) signal of about 100 kHz.

Electrical output of the amplifier 66 is electrically connected to a switch 68 (Fig. 10), such as a multiplexer and the like, which directs the signal to the conductor 44 associated with at least one receptacle 30 (Fig. 4) or to one of two reference resistor circuits 70. Electromagnetic coupling between the conductor 44 and the conductor 46, due at least in part to electrical transmissive properties of the fluid, causes an electrical signal to be received by the conductor 46. The amplitude of the electrical signal received by the conductor 46 is a function of fluid volume within the receptacle 30. The reference resistor circuits 70 may be voltage dividers, such as an about 10 k Ω resistor and an about 700 Ω resistor electrically connected in series, to yield an output voltage that is a known and substantially constant fraction of an input voltage.

The electrical signal received by the conductor 46 is electrically connected via a buffer 72 (Fig. 12) to the switch 68. The switch 68 electronically connects the conductor 46 from the selected receptacle 30 to the remainder of the circuit 61. The switch 68 may be a dual multiplexer with an address input 74 (Fig. 10) from the feedback mechanism 14 or may be two multiplexers controlled so that both the conductor 44 and the conductor 46 associated with a given receptacle 30 are connected to the circuit 61 simultaneously.

The electrical signal from the switch 68 is electrically connected via an amplifier 76 to a filter 78 (bandpass). The amplifier 76 has a gain of about 20. The filter 78 has a passband of about 60 kHz centered at about 100 kHz. The filter
5 78 is electrically connected with a buffer 80. The output of the buffer 80 feeds into a rectifier 82 (full wave) and an integrator 84 (active). Details of the amplifier 76, the filter 78 and the buffer 80 are illustrated in Figs. 9A and 9B. Details of the rectifier 82 and the integrator 84 are shown in
10 Fig. 11.

The output of the integrator 84 is a substantially steady direct current voltage which is approximately linearly related to an amplitude of the electrical signal received by the conductor 46. This output is indicative of a volume of fluid
15 disposed in the selected receptacle 30. This direct current voltage is applied to an amplifier 86 (Fig. 11), with a gain of about 5, that imposes an adjustable offset of the order of about 8.8 Volts (DC). The offset, controlled by an adjustable reference voltage circuit 88 (Fig. 11), is set prior to use of
20 the apparatus 10 by substantially filling all of the associated receptacles 30 with about 350 μ l of a fluid, such as degassed, deionized water and the like, and adjusting the offset so that all receptacles 30 yield an output voltage of about 0.0 Volts (DC). The output of the amplifier 86 is an electrical signal
25 that varies between about 0 Volts (DC) and about +5 Volts (DC). The output of the amplifier 86 is transmitted along conductor 90 to the feedback mechanism 14.

The feedback mechanism 14, shown in Fig. 8, generally contains an analog to digital converter 92 which, in this
30 embodiment, is a 17 bit converter with sign. The converter 92 converts the output voltage from the sensor unit 12 to a numerical value. The feedback mechanism 14 also includes the display 32 to display the numerical value from the converter 92 or another numerical value. The feedback mechanism 14 also
35 includes a energy supply unit 94 to receive electrical energy

from the source 16 of electrical energy to supply electrical energy to the components of the feedback mechanism 14 and the sensor unit 12. The feedback mechanism 14 also may contain data processing circuitry 96 (such as a microcontroller and the like) to control operation of the apparatus 10, an input/output circuit 98 which acts as an interface between the feedback mechanism 14 and the sensor unit 12, and communication circuitry 100 (such as an RS-232 serial transfer device and the like) to transmit data to the computer 26 or some other device for further processing, evaluation, or storage.

In this embodiment, the microcontroller 96 sends a three-bit binary address signal via the input/output circuit 98 to the sensor unit 12 that corresponds to the desired receptacle 30 or reference resistor circuit 70. The three-bit binary address signal is applied to the address lines 74 of the switch 68. The electrical signal indicative of the volume of fluid disposed in the selected receptacle 30 is applied to the analog to digital converter 92. The analog to digital converter 92 produces a digital numerical signal which is transmitted via the communication device 100 to the computer 26 and may also be displayed on the display 32.

With the construction of an embodiment of an apparatus for verifying a volume of a fluid being disclosed in detail, an embodiment of a method of verifying a volume of fluid or operation of the apparatus 10 will now be disclosed. For the sake of clarity, the methods will be discussed in relation to the apparatus 10. However, the methods may be employed with any suitable mechanism. A plurality of methods are detailed.

In general, one method of checking or verifying a volume of fluid comprises the following steps. The apparatus 10 is positioned with respect to the analytical instrument 18 such that a receptacle 30 is operatively connected with a fluid dispense nozzle on the instrument 18. The operative connection between the receptacle 30 and the dispense nozzle is such that fluid exiting the dispense nozzle enters the receptacle 30.

Fluid exits the dispense nozzle and enters the receptacle 30. An electrical signal is applied to the conductor 44. An electrical signal is created in the conductor 46 responsive to the electrical signal applied to the conductor 44. The electrical signal created in the conductor 46 is monitored. Because an amplitude of or a voltage associated with the electrical signal created in the conductor 46 is related to the volume of fluid present in the receptacle 30, appropriate monitoring of the electrical signal created in the conductor 46 provides an indication of the volume of fluid within the receptacle 30. The apparatus 10 provides feedback to an operator or a computer corresponding to the volume of fluid within the receptacle 30.

More specifically, the following methods can be used along with the apparatus 10, or an equivalent device, to verify a volume of fluid.

System calibration

The apparatus 10 may be calibrated by performing the following method steps.

1. Using a mass balance, determine a volume of fluid dispensed by a precision test pump. In one embodiment, the volume of fluid measures about 50 μ l. The test pump may be a valveless metering pump such as that described in U.S. Patent No. 5,246,354. That patent is assigned to the assignee of the present application. The disclosure of that patent is incorporated herein by reference. The pump should be primed prior to use.
2. Install liners 58 in apertures 31 in the sensor unit 12 and rinse the liners 58.
3. Fill all receptacles 30 with about 350 μ l of degassed, deionized water.

4. Adjust the reference circuit 88 so that the digital output of the analog to digital converter 92 for all channels is greater than about -45,000.

5

5. Make about 6 additions, measuring of about 50 μ l each, of degassed, deionized water to each receptacle 30 from the precision test pump. While making these additions, monitor the output of the analog to digital converter 92.

10

6. Calculate the average change in output of the analog to digital converter 92 for each addition of degassed, deionized water to each of the receptacles 30. The slope is approximately equal to the difference in counts between a period following the initial dispense of about 350 μ l of water and a period after the about 6 additional dispenses of water multiplied by 50 and divided by the actual volume dispensed (6 times the precision test pump dispense volume). This slope may be used for volume verification and may be stored in an appropriate memory, such as a RAM, a ROM, an EPROM, a SRAM and the like, which may be located in the feedback mechanism 14.

Volume verification

To verify a volume of fluid dispensed by a pump in an analytical instrument 18 with the apparatus 10, the apparatus 10 is calibrated as discussed above. After calibration, the following steps are performed.

30

1. Install new liners 58 in the sensor unit 12.

2. Prime the dispense pump by dispensing fluid from the dispense pump at least about 10 times.

3. Make available the slope data, determined during calibration, for the sensor unit 12.

35

4. Add about 350 μl of degassed, deionized water to each of the receptacles 30.

5. Make 6 additions of about 50 μl each of degassed, deionized water to each receptacle 30 from the precision test pump. While making these additions, monitor the output of the analog to digital converter 92.

6. For each dispense, calculate the volume of the dispensed water by multiplying the difference in counts from the analog to digital converter 92 before and after the dispense by 50 μl and by dividing by the slope determined in the calibration process.

7. Calculate the mean and the coefficient of variation of the dispensed volume.

In an example of the above method steps, a test pump was adjusted to dispense about 47.5 μl of degassed, deionized water, as measured by a mass balance. In 12 verification runs, the average error detected by the apparatus 10 was about 0.21 μl or about 0.42 percent (with a range of about 0.0 μl to about 0.63 μl or substantially within the range of about 0.0% to about 1.26%). The coefficient of variation of dispensed volume readings within the twelve runs averaged about 0.88 percent (with a range of about 0.18% to about 1.95%).

Automated reading

An example of software that may be used to operate or process information from the apparatus 10 is presented at the end of this discussion and preceding the claims. This software, written in structured BASIC, may be executed by the computer 26 which may or may not be integrated with the instrument 18. The routine performs the following steps. Relevant portions of the

routine are flagged by **STEP** and the number of the step, which corresponds to the numbers below.

1. Establish communication via the communication circuit
5 100 between the computer 26 that is executing the software routine and the feedback mechanism 14.
2. Select a receptacle 30. A data packet indicating this receptacle 30 is transmitted to the feedback mechanism 14.
10 The feedback mechanism 14 converts this data packet to a three-bit digital address signal that is transmitted to the sensor unit 12 via the address lines 74.
3. The digital output from the analog to digital
15 converter 92 of the feedback mechanism 14 is received by the computer 26 via the communication circuit 100. This step is executed in the subroutine entitled "RCV," which contains two steps.
- 20 3a. Each serial data packet, in one embodiment one byte representing an ASCII character, from the communications circuit 100 of the feedback mechanism 14 is received as a character value.
- 25 3b. The data received from the communication circuit 100 is appended to preceding data packets to form a character string. The signal normally consists of a series of ASCII characters, the first eight of which are the decimal value of the analog to digital converter 92 output
30 and the ninth which is the decimal value of a channel number, which corresponds to a location on the analytical instrument 18. The seven most significant digits of the analog to digital converter 92 output are used in volume calculations.
35

4. The character string is converted to two numerical values representing the analog to digital converter 92 output and the channel number.

- 5 5. The volume of dispensed fluid is displayed and/or printed.

Automated verification of dispense volume of fluid

10 A software routine that may be used with an embodiment of an apparatus to verify a volume of fluid is presented before the claims. This software routine, written in structured BASIC, may be executed on a computer 26. This routine incorporates the routines described above to determine output of the analog to digital converter 92 with additional routines included to
15 execute the following steps.

1. Communication is established via a serial data link between the computer 18 that is executing the software routine and the feedback mechanism 14.

20

2. The value of the calibration slopes for the various receptacles 30 are read from a preexisting data file. This data file was created using a procedure similar to that described with respect to System calibration.

25

3. Communication is established between the computer 26 that is running the software routine and the analytical instrument 18.

30

4. A receptacle 30 is selected for performing verification of a dispensed volume of fluid. This selection may be made by the operator directly or by a routine associated with the analytical instrument 18.

5. The output of the analog to digital converter 92 is monitored by the routine during an initial dispense of about 450 μ l of fluid into the receptacle 30. The output values are read using the routines described above.

5

6. The output of the analog to digital converter 92 is allowed to stabilize.

7. Readings from the reference resistor circuits 70 are
10 taken.

8. The output of the analog to digital converter 92 is monitored by the routine during dispense of about 50 μ l of fluid into the receptacle 30. There may be a plurality of such
15 dispenses. The output values are read using the routines described above, located in subroutines "DBLREAD" and "RCV."

9. The output of the analog to digital converter 92 is allowed to stabilize.
20

10. The numerical value of the analog to digital converter 92 output is stored in suitable memory, such as a RAM, a ROM, an EPROM, a SRAM and the like.

11. Steps 8-10 are repeated for the desired number, such
25 as 6, of dispenses of fluid in the selected receptacle 30.

12. Readings from the reference resistor circuits 70 are taken.

30

13. The difference in the analog to digital converter 92 output, representing the volume of fluid associated with each dispense, is calculated.

14. The mean dispense volume and standard deviation of the dispense volumes are calculated, along with the deviation from the mean for each individual dispense. This step is executed within the subroutine "CALCULATE."

5

15. For each of the dispenses performed and verified, the volume of the dispense of fluid is calculated, is printed and/or is displayed and is stored in a record file.

10 16. The mean and standard deviation of the dispensed volume for all dispenses are printed.

17. The mean and coefficient of variation are compared to a predetermined "pass" criteria.

15

The methods discussed herein may be controlled or executed manually or by a controller, such as the computer 26 and the like, or may be controlled by software residing on and running within memory comprising the analytical instrument 18. By verifying a dispensed volume of fluid, an implicit test of the fluid delivery system, comprising a fluid source, a pump, a fluid conveying conduit, a dispense nozzle, etc., is made. Thus, the apparatus and method described herein may give an operator an indication of status of elements of a fluid system associated with the analytical instrument 18.

A listing of the above-discussed software routines follows presently. The STEP numbers correlate to the numbers used in the above discussion.

30

STEP 1

```
*****INITIALIZE METER INTERFACE*****  
OPEN "COM1:9600,N,8,1,BIN,CD0,CS0,DS0,RS,TB256,RB32000" FOR  
RANDOM AS #1'RF METER SERIAL CONNECTION  
CALL Delay(300)
```

35

```
x = INP(&H3FC) ' set CTS and DTR  
x = x OR 3  
OUT &H3FC, x
```

DBLREAD:

*****inner read loop

```

5  VIEW PRINT 14 TO 23
   LOCATE (14 + j), 1
   IF j > 0 THEN PRINT USING "      ##      "; j;

```

STEP 2

```

10 SELECT CASE chan
    CASE 1: PRINT #1, "M4"
    CASE 2: PRINT #1, "M1"
    CASE 3: PRINT #1, "M3"
    CASE 4: PRINT #1, "M0"
15  CASE 5: PRINT #1, "M5"
    CASE 6: PRINT #1, "M2"
    END SELECT

```

CALL RCV

```

20  CALL Delay(READDEL) 'delay for apres mux

```

PRINT #1, "R"

STEP 3

```

25  CALL RCV
    *****
    SS = MID$(sbuff$, 3, 10) + " "
    S = VAL(LEFT$(SS, 8)) / 32

```

```

30  oldchana = chana

```

STEP 4

```

    chana = VAL(LEFT$(SS, 7))
    chnum = VAL(MID$(SS, 9, 1))
35  diffa = oldchana / 32 - S

```

STEP 5

```

    IF j > 0 THEN PRINT USING "      ###.## uL"; (ABS((rdata(chan, j
- 1, 1) - chana) / 32)) * 50 * 32 / slope(chan);

```

```

40  RETURN

```

SUB RCV

*****RECEIVE DATA FROM METER*****

```

45  SCOUNT = (VAL(RIGHT$(TIMES, 2))) + 3
    IF SCOUNT > 59 THEN SCOUNT = SCOUNT - 60

```

AS = ""

sbuff\$ = ""

50

21

```

DO
    IF LOC(1) > 0 THEN
        ALASTS = A$
5
    STEP 3a
    A$ = INPUT$(1, #1)
    STEP 3b
10    IF NOT (A$ = CR$) THEN sbuff$ = sbuff$ + A$

    END IF

    SCOUNT2 = VAL(RIGHT$(TIMES$, 2))
15    IF SCOUNT = SCOUNT2 THEN
        PRINT
        PRINT "***ERROR*** METER NOT RESPONDING - Check cables and
            power"
        PRINT
20    BEEP
        IF RMX THEN CALL sendrmx(14)          'ESCAPE (HEX 'E')
        SYSTEM
    END IF

25    IF LFFLAG > 0 AND A$ = LFS THEN A$ = ">"
    LOOP WHILE NOT (A$ = ">")

    x = LOC(1)
    IF x > 256 THEN PRINT "X>256"; x
30
    END SUB

' RFAUTO.Bas => RMX=-1  RFCAL.BAS => RMX=0  RFBENCH.BAS => BENCH=-1
35
'takes .DAT files from PRISM CDS A/D DATA CAPTURE, finds the dispense point
'by looking at point-to-point differences, calculates the mean of the last
'20 points prior to dispense, and stores results in VOL.DAT

40 'COPYRIGHT ABBOTT LABORATORIES 1994
'AUTHOR: J Kotlarik
' This version uses a BIOS SW INTERRUPT for machine-independant timing.
' Note: To use CALL INTERRUPT, you must load the Quick library QB.LIB
' with QuickBASIC. The program also uses the QB.BI header file.
45 ' If compiling fails to find QB.LIB, use the following commands
' from the 2nd QB45 (UTILS) disk: UNPACK QB.LIB QB.LIB

' Use the following command line when you start QB :

50 ' QB RFAUTO /L QB

```

```

' Include header file for INT86OLD, etc.
'$INCLUDE: 'QB.BI'

DECLARE SUB Delay (counts!)
5  DECLARE SUB BENCHDISP ()
  DECLARE SUB DISPTRAY (chan!)
  DECLARE SUB GETREFS (LOWREF$, HIGHREF$)
  DECLARE SUB RCV ()
  DECLARE SUB sendrmx (rmxsnd)
10  DECLARE SUB getrmx ()
  DECLARE SUB GETNEWKEY (NEWKEY$)
  DECLARE SUB TESTREF ()
  COMMON SHARED sbuff$
  COMMON SHARED CR$
15  COMMON SHARED LF$
  COMMON SHARED ESC$
  COMMON SHARED BS$
  COMMON SHARED diffa, diffb
  COMMON SHARED RMX
20  COMMON SHARED Raw
  COMMON SHARED rmxdatardy
  COMMON SHARED rmxrcv
  COMMON SHARED LFFLAG
  COMMON SHARED NEWKEY$
25  COMMON SHARED DEBUG
  COMMON SHARED READDEL
  COMMON SHARED PPORTOUT%
  COMMON SHARED PPORTIN%

30  'Rev$ = "1.0"   '1/19/94 Program creation
  'Rev$ = "1.1"   '2/17/94 Added Statistics and auto-linear range detection
  'Rev$ = "1.2"   '6/16/94 Interfaced to Eutechnics Meter/Controller
  'Rev$ = "1.3"   '8/12/94 Auto-prime and auto-dispense detect
  'Rev$ = "1.4"   '10/21/94 RMX and machine id
35  'Rev$ = "1.5"   '11/3/94 rewrite commRMX and machine id
  'Rev$ = "1.6"   '11/22/94 Get from BIOS PP data and status reg address
  'Rev$ = "1.7"   '11/29/94 Allow Parallel comm with benchtop fixture
  'Rev$ = "1.8"   '12/03/94 Save and read slopes from meter

40  DIM rdata(6, 21, 3)
  DIM ref(6, 2, 2)
  DIM rarray(21, 4)
  DIM slope(6)
  DIM PUMPLIST$(10)
45  CR$ = CHR$(13): ESC$ = CHR$(27)
  LF$ = CHR$(10): BS$ = CHR$(8)

  DEBUG = 0 'IF DEBUG = -1 THEN ALL TEST DATA DISPLAYED ELSE = 0

```

RMX = 0 'IF RMX = 0 THEN PRISM RMX - PC PARALLEL PORT DISABLED -1 -> ENABLED
BENCH = 0 'IF BENCH = 0 THEN PARALLEL COM DISABLED -1 -> ENABLED

VALIDATE = 1

5 GROUP.SIZE = 20

PUMPLIST\$(1) = "MP"

PUMPLIST\$(2) = "SD"

PUMPLIST\$(3) = "PR"

10 PUMPLIST\$(4) = "PW"

PUMPLIST\$(5) = "CO"

PUMPLIST\$(6) = "CW"

PUMPLIST\$(7) = "AC"

PUMPLIST\$(8) = "SA"

15 PUMPLIST\$(9) = "SM"

*****GET LPT1 PORT ADDRESS*****

DEF SEG = &H40

Pपोर्टOUT% = PEEK(&H8) + (PEEK(&H9) * 256)

20 Pपोर्टIN% = Pपोर्टOUT% + 1

DEF SEG

rerun:

25

CLS

VIEW.PRINT 1 TO 2

IF RMX THEN

PRINT " ABBOTT PRISM RF VOLUME VALIDATION REV. ";

30 ELSE

PRINT " ABBOTT PRISM RF VOLUME VALIDATION TRAY CALIBRATION REV. ";

END IF

PRINT Rev\$

35

PRINT " Copyright Abbott Laboratories 1994";

Delay (15000)

slope = 20

40

SAMPLE = 0

ENDCNT = 6 'number of shots

READDEL = 10500

PRIMESTART = 100 'PRIME START READ-TO-READ DIFFERENCES

45

PRSTARTCNT = 3 'PRIME START NUMBER OF REPS NEEDED TO STABILIZE

PRIMEDIFF = 1.5 'PRIME SETTLE READ-TO-READ DIFFERENCES

PRIMEREPS = 3 'PRIME SETTLE NUMBER OF REPS NEEDED TO STABILIZE

DIFF = .9 'NORMAL DISPENSE READ-TO-READ DIFFERENCES
 DIFFREPS = 3 'NORMAL DISPENSE NUMBER OF REPS NEEDED TO STABILIZE
 'check for a command line parameter containing the filename to process

5 *****INITIALIZE METER INTERFACE*****

STEP 1

OPEN "COM1:9600,N,8,1,BIN,CD0,CS0,DS0,RS,1B256,RB32000" FOR RANDOM AS #1'RF
 METER SERIAL CONNECTION
 10 CALL Delay(300)

x = INP(&H3FC) ' set CTS and DTR
 x = x OR 3
 OUT &H3FC, x

15 PRINT #1, ESC\$;
 CALL RCV

ON ERROR GOTO noslope:
 20 FOR i = 1 TO 6
 PRINT #1, "G" + LTRIM\$(RTRIM\$(STR\$(i))) + CR\$

STEP 2

CALL RCV

25 TEMP\$ = LEFT\$(sbuff\$, LEN(sbuff\$))
 TEMP\$ = LTRIM\$(RTRIM\$(TEMP\$))
 slope(i) = VAL(TEMP\$)
 IF slope(i) = 0 THEN slope(i) = 5000
 CALL RCV

30 NEXT

GOTO NOMACHINEID

35 continueinit:

VIEW PRINT 25 TO 25
 PRINT " -For Investigational Use Only-";

40 VIEW PRINT 1 TO 2
 LOCATE 2, 1
 PRINT SPACES\$(79);

IF NOT RMX THEN

45 LOCATE 2, 3
 PRINT "PRISM NUMBER " + MACHINEID\$ + " Is this correct? (Y/N or ENTER) >";
 DO
 CALL GETNEWKEY(NEWKEY\$)

25

```

LOOP WHILE NEWKEY$ = ""
NEWKEY$ = UCASE$(NEWKEY$)
IF NOT (NEWKEY$ = "Y" OR NEWKEY$ = CR$) THEN GOTO newmachineid
END IF

5  ON ERROR GOTO errorhandler

IF COMMAND$ <> "" THEN
  L = INSTR(COMMAND$, " ")
10  IF L > 0 THEN
    inputfilename$ = LEFT$(COMMAND$, L - 1)
    slope$ = RIGHT$(COMMAND$, LEN(COMMAND$) - L)
    slope = VAL(slope$)
  ELSE
15  inputfilename$ = COMMAND$
    slope = 0
  END IF
END IF

20

*****RMX Parallel Port INIT Start*****

STEP 3
25  VIEW PRINT 3 TO 23
  LOCATE 4, 1
  IF RMX THEN
    PRINT "Waiting for PRISM RMX Handshake...";

30  ' init port Set READY high here - low at remote INVERTED SIGNAL BIT 4 OUTPUT
    ' to BIT 7 INPUT

    ' SEND 5 THEN A CONTINUOUSLY UNTIL 5 AND A BOTH RECEIVED FROM RMX
    ' AFTER BOTH 5 AND A RCVD, SENDS 15H THEN 1AH UNTIL READY FROM RMX

35  RMX5 = 0
    RMXA = 0
    STATUS = 0

40  DO

    OUT PPORTOUT%, &H5 OR STATUS
    FOR x = 1 TO 20
      NEWRMX = INP(PPORTIN%)
45  STATUSRMX = NEWRMX AND &H80
      NEWRMX = (NEWRMX AND &H78) / 8 'CORRECT FOR DATA SHIFT UP 3 BITS BY LAPLINK
      CABLE
      IF NEWRMX = 5 THEN RMX5 = -1
      IF NEWRMX = &HA THEN RMXA = -1

```

26

```

NEXT

OUT PPORTOUT%, &HA OR STATUS

5  FOR x = 1 TO 20
    NEWRMX = INP(PPORTIN%)
    STATUSRMX = NEWRMX AND &H80
    NEWRMX = (NEWRMX AND &H78) / 8 'CORRECT FOR DATA SHIFT UP 3 BITS BY LAPLINK
    CABLE
10  IF NEWRMX = 5 THEN RMX5 = -1
    IF NEWRMX = &HA THEN RMXA = -1
    NEXT

    IF ((RMX5 <> 0) AND (RMXA <> 0)) THEN STATUSOUT = &H10
15  LOOP WHILE ((RMX5 = 0) OR (RMXA = 0) OR (STATUSRMX = &H80))

    'SEND READY
    OUT PPORTOUT%, &H10
20  ' Wait for remote READY (low here - high at remote)
    DO
        r = INP(PPORTIN%)
        r = r AND &H80
25  LOOP WHILE r <> 0 'loop until low

    PRINT "Received!";
    SLEEP 1

30  VIEW PRINT 1 TO 2
    CLS (2)
    LOCATE 1, 1
    IF RMX THEN
        PRINT "      ABBOTT PRISM RF VOLUME VALIDATION REV. ";
35  ELSE
        PRINT "      ABBOTT PRISM RF VOLUME VALIDATION TRAY CALIBRATION REV. ";
    END IF

    PRINT Rev$;
40  END IF
    .....RMX  Parallel  Port  INIT  End.....

    CALL DISPTRAY(0)

45  IF NOT RMX THEN
    logfilename$ = MACHINEID$ + LEFT$(DATE$, 2) + MID$(DATE$, 4, 2) + "."

    ' Get the run number this setup w/today's date
    count = 1

```

27

```

DO
    count$ = LTRIM$(STR$(count))
    IF count < 10 THEN count$ = "0" + count$
5    OPEN logfilename$ + "V" + count$ FOR APPEND AS #11

    IF LOF(11) = 0 THEN
        logfilename$ = logfilename$ + "V" + count$
10    EXIT DO
    ELSE
        count = count + 1
    END IF

15    CLOSE #11
    LOOP UNTIL count > 36
    runnumber = count
    CLOSE #11

20    VIEW PRINT 1 TO 2
    LOCATE 2, 1
    PRINT SPACES$(79);

    LOCATE 2, 1
25    PRINT " PRISM " + MACHINEID$ + "          File-" + logfilename$ + "          " +
    DATES;
    VIEW PRINT 14 TO 23
    .....

30    END IF

    .....SELECT    WELL    PAIR.....

DO
35    VIEW PRINT 3 TO 4

    CLS (2)
    PRINT

40    STEP 4
    IF RMX THEN
        PRINT "          ENTER TEST INFORMATION ON PRISM-          ";
    ELSE PRINT "          SELECT WELL PAIR (1)=1,2 (3)=3,4 (5)=5,6 ENTER [1,3,5]>";
    END IF

45    x = 0
    DO
        CALL GETNEWKEY(NEWKEY$)

        .....RMX    Parallel    Port    WELL    PAIR    Start.....

```

IF RMX THEN

getchan:

```
CALL getrmx
5 IF rmxrcv <> 6 THEN GOTO getchan'LOOK FOR CHANNEL NUMBER SELECT COMMAND (7)
DO
  CALL getrmx
  x = rmxrcv 'Get channel number (1-6)
  LOOP WHILE x = 0
10 channelnumber = x
  'PRINT " Channel "; channelnumber
```

getpumpno:

```
CALL getrmx
15 IF rmxrcv <> 7 THEN GOTO getpumpno 'LOOK FOR PUMP NUMBER SELECT COMMAND (6)
DO
  CALL getrmx
  x = rmxrcv 'Get pump number (1-9)
20 LOOP WHILE x = 0
  PUMPNUMBER = x
  'PRINT " Pump # "; pumpnumber
```

getprid:

```
25 CALL getrmx
IF rmxrcv <> 8 THEN GOTO getprid 'LOOK FOR PRISM UNIT ID NUMBER COMMAND (8)
DO
  CALL getrmx
  x = rmxrcv 'Get PRISM Unit ID number digit 1 of 3 (0-9)
30 LOOP WHILE (rmxdatardy = 0)
  prismno1 = x
```

```
DO
  CALL getrmx
35 x = rmxrcv 'Get PRISM Unit ID number digit 2 of 3 (0-9)
  LOOP WHILE (rmxdatardy = 0)
  prismno2 = x
```

```
DO
40 CALL getrmx
  x = rmxrcv 'Get PRISM Unit ID number digit 3 of 3 (0-9)
  LOOP WHILE (rmxdatardy = 0)
  prismno3 = x
```

```
45 IF prismno3 = 10 THEN prismno3$ = "" ELSE prismno3$ = STR$(prismno3)
IF prismno2 = 10 THEN prismno2$ = "" ELSE prismno2$ = STR$(prismno2)
IF prismno1 = 10 THEN prismno1$ = "" ELSE prismno1$ = STR$(prismno1)
```

```
prismid$ = LTRIM$(prismno1$) + LTRIM$(prismno2$) + LTRIM$(prismno3$)
```

29

```

      idcnt = LEN(prismid$)
      IF idcnt = 1 THEN prismid$ = "00" + prismid$
      IF idcnt = 2 THEN prismid$ = "0" + prismid$

5      prismid = VAL(prismid$)
      'PRINT " PRISM " + prismid$
      MACHINEID$ = prismid$

10      .....
      'create filename for this run

      logfilename$ = MACHINEID$ + LTRIM$(STR$(channelnumber)) + LEFT$(DATE$, 2) +
      MID$(DATE$, 4, 2) + "."

15      ' Get the run number this setup w/today's date
      count = 1

      DO
20      count$ = LTRIM$(STR$(count))
      IF count > 9 THEN count$ = asc$(count + &H31) 'count >9 -> "A-Z"

      OPEN logfilename$ + PUMPLIST$(PUMPNUMBER) + count$ FOR APPEND AS #11

25      IF LOF(11) = 0 THEN
          logfilename$ = logfilename$ + PUMPLIST$(PUMPNUMBER) + count$
          EXIT DO
      ELSE
          count = count + 1
30      END IF

      CLOSE #11
      LOOP UNTIL count > 36
      runnumber = count
35      CLOSE #11

      VIEW PRINT 1 TO 2
      LOCATE 2, 1
40      PRINT SPACE$(79);

      LOCATE 2, 1
      PRINT " PRISM " + MACHINEID$ + " File-" + logfilename$ + " Channel ";
      channelnumber; " " + PUMPLIST$(PUMPNUMBER) + " Pump " + DATE$;
45      VIEW PRINT 14 TO 23

      .....

      getcupno:

```

30

```

x = 0
CALL getrmx
IF rmxcv <> 1 THEN GOTO getcupno 'LOOK FOR well-pair SELECT COMMAND (1)
DO
5   CALL getrmx
    x = rmxcv      'Get well pair (1,3,5)
    LOOP WHILE x = 0
    cupnumber = x

10  END IF
    .....RMX  Parallel Port WELL PAIR End.....

    LOOP WHILE (NEWKEY$ = "") AND (x = 0)
15  IF x = 0 THEN x = VAL(NEWKEY$)

    LOOP WHILE NOT (x = 1 OR x = 3 OR x = 5)
    .....

20  VIEW PRINT 14 TO 23
    chan = x
    chana$ = asc$(x)
    chanb$ = asc$(x + 1)
    .....START OF CHANNEL DATA COLLECTION.....

25  PRINT #1, ESC$;
    CALL RCV

    chana$ = LTRIM$(STR$(chan))
    chanb$ = LTRIM$(STR$(chan + 1))
30  stub$ = "D+ " + chana$ + " " + chanb$

    PRINT #1, stub$ + CR$
    CALL RCV

35  .....TRAY STABILITY CHECK.....

    CALL TESTREF
    .....

40  VIEW PRINT 4 TO 5
    CLS (2)
    PRINT
    IF (RMX OR BENCH) THEN
        PRINT "      WAIT FOR PRISM TO PRIME WELLS      "
45  ELSE
        PRINT " FILL CUPS " + chana$ + " and " + chanb$ + " WITH 350 uL FLUID THEN WAIT
        FOR BEEP WHILE READS STABILIZE";
        BEEP
    END IF

```

INTERNATIONAL SEARCH REPORT

Information on patent family members

In International Application No
PCT/US 96/00611

Patent documents cited in search report	Publication date	Patent family members	Publication date
EP-A-0338400	25-10-89	DE-A- 3812687 DE-D- 58908161	26-10-89 15-09-94
US-A-4107993	22-08-78	NONE	
US-A-5275951	04-01-94	AU-B- 2193492 AU-B- 2250892 AU-B- 2257592 AU-B- 2259592 AU-B- 2266892 CA-A- 2109944 EP-A- 0588931 EP-A- 0588967 EP-A- 0588968 EP-A- 0588969 EP-A- 0588972 JP-T- 6507495 JP-T- 6507496 JP-T- 6507497 JP-T- 6507498 JP-T- 6507499 WO-A- 9222800 WO-A- 9222879 WO-A- 9222801 WO-A- 9222802 WO-A- 9222880	12-01-93 12-01-93 12-01-93 12-01-93 12-01-93 23-12-92 30-03-94 30-03-94 30-03-94 30-03-94 30-03-94 25-08-94 25-08-94 25-08-94 25-08-94 25-08-94 23-12-92 23-12-92 23-12-92 23-12-92 23-12-92
EP-A-0426622	08-05-91	NONE	
US-A-5351036	27-09-94	CA-A- 2124695 EP-A- 0616687 JP-T- 7504977 WO-A- 9312408	24-06-93 28-09-94 01-06-95 24-06-93

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 96/00611

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation Document, with indication, where appropriate, of the relevant	Relevant to claim No.
A	EP,A,0 426 622 (ITAL IDEE SRL) 8 May 1991 see column 3, line 10 - line 40 see column 5, line 10 - line 25; claim 1; figure 3 ---	1-12
A	US,A,5 351 036 (BROWN DAVID P ET AL) 27 September 1994 see column 11, line 40 - column 12, line 35; claims 1,32; figures 2,3,7 ---	1-12
A	PATENT ABSTRACTS OF JAPAN vol. 010, no. 252 (C-369), 29 August 1986 & JP,A,61 078458 (SHIMADZU CORP), 22 April 1986, see the whole document -----	1-12

INTERNATIONAL SEARCH REPORT

In International Application No

PCT/US 96/00611

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01F23/

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 338 400 (DUERRWAECHTER E DR DODUCO) 25 October 1989 see page 2, line 23 - page 3, line 6; claim 1; figure 1 ---	1-12
X	US,A,4 107 993 (SHUFF THOMAS J ET AL) 22 August 1978 see column 2, line 15 - column 3, line 22 see column 4, line 57-69; figures 1,2 ---	1-12
A	US,A,5 275 951 (CHOW HERBERT S ET AL) 4 January 1994 see column 3, line 40-45 see column 6, line 40 - column 7, line 20; claim 1; figure 7 --- -/-	1-12

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- *&* document member of the same patent family

Date of the actual completion of the international search

22 May 1996

Date of mailing of the international search report

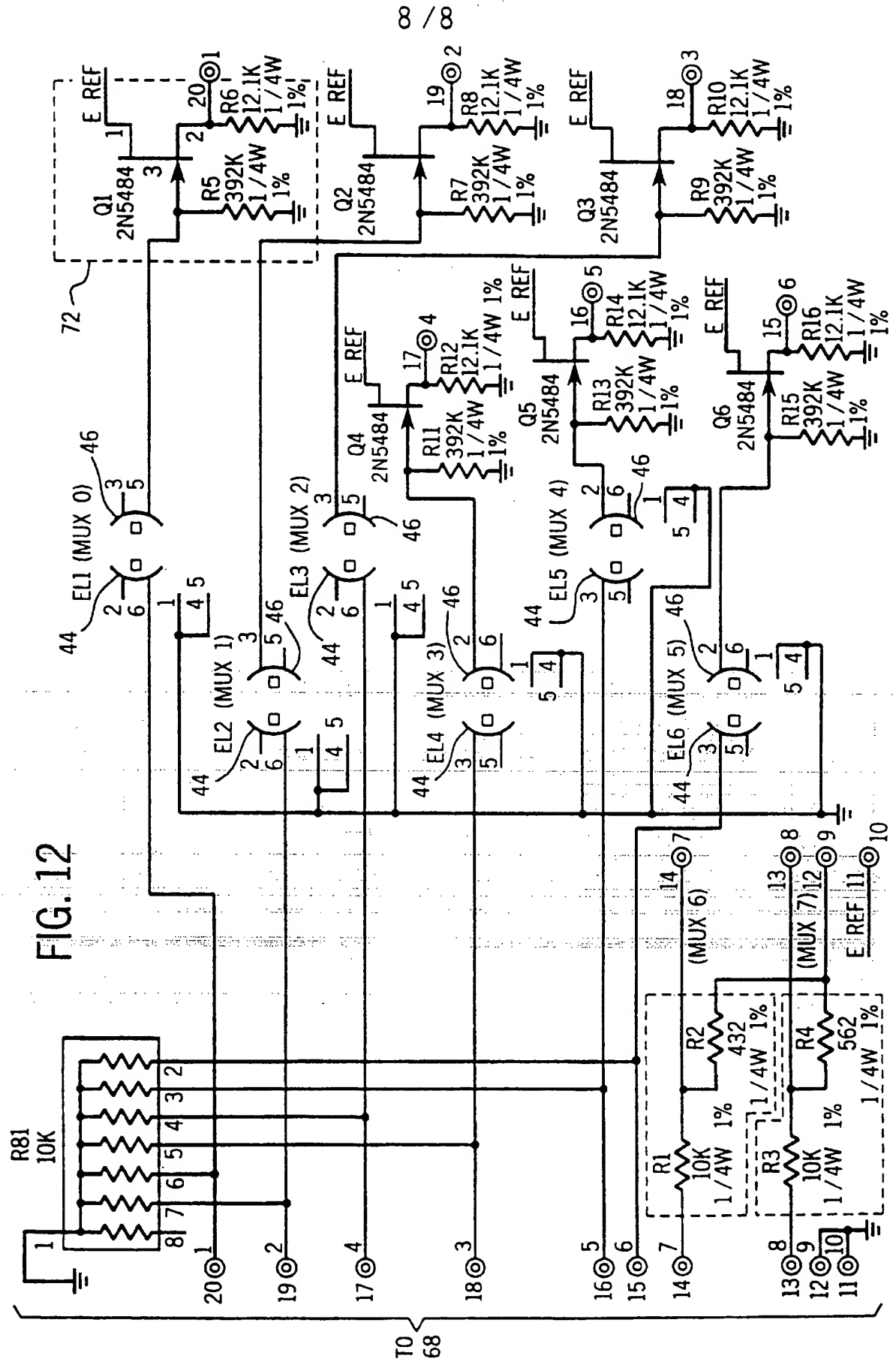
20.06.96

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+ 31-70) 340-3016

Authorized officer

Mason, W



7 / 8

FIG. 11

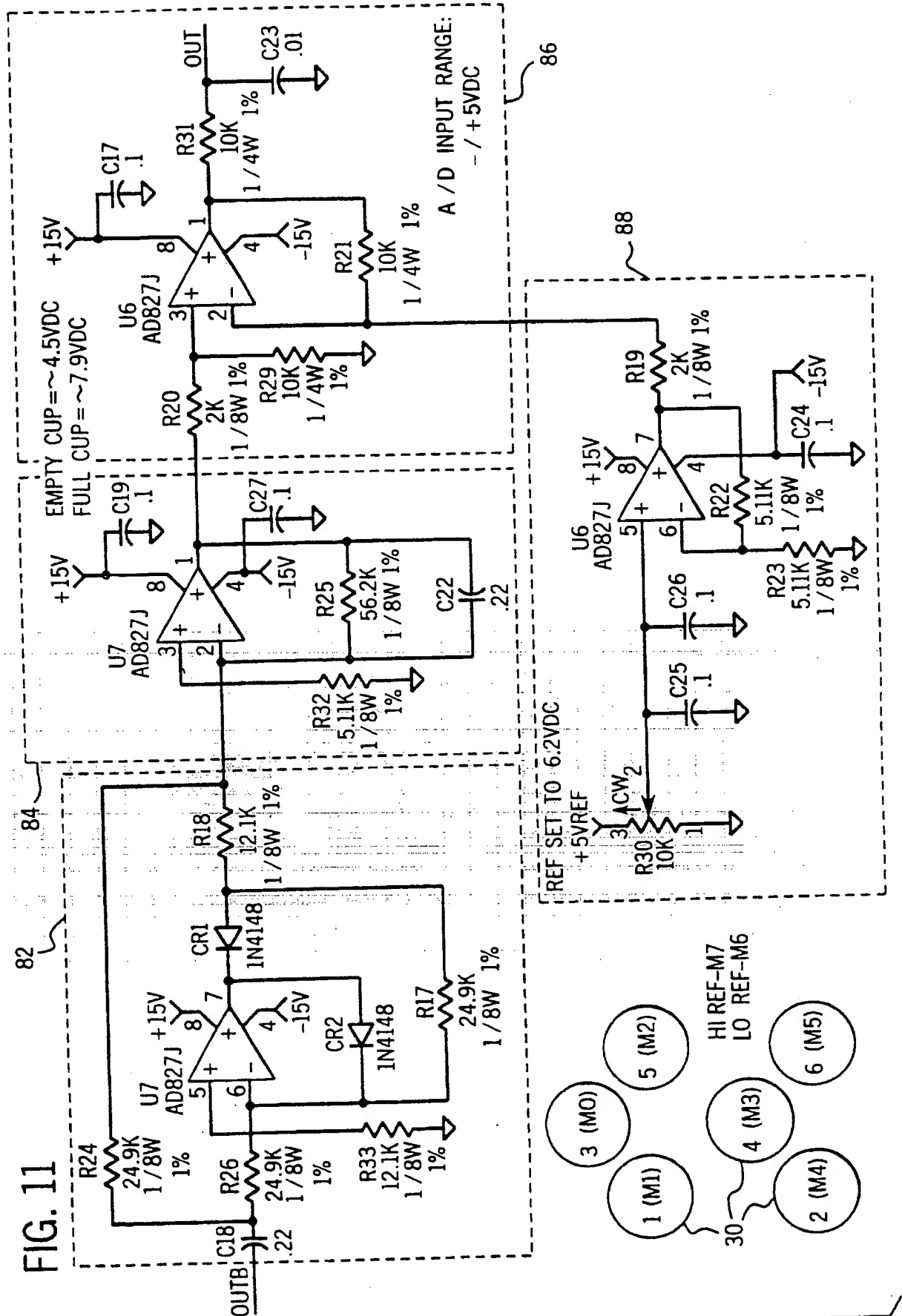
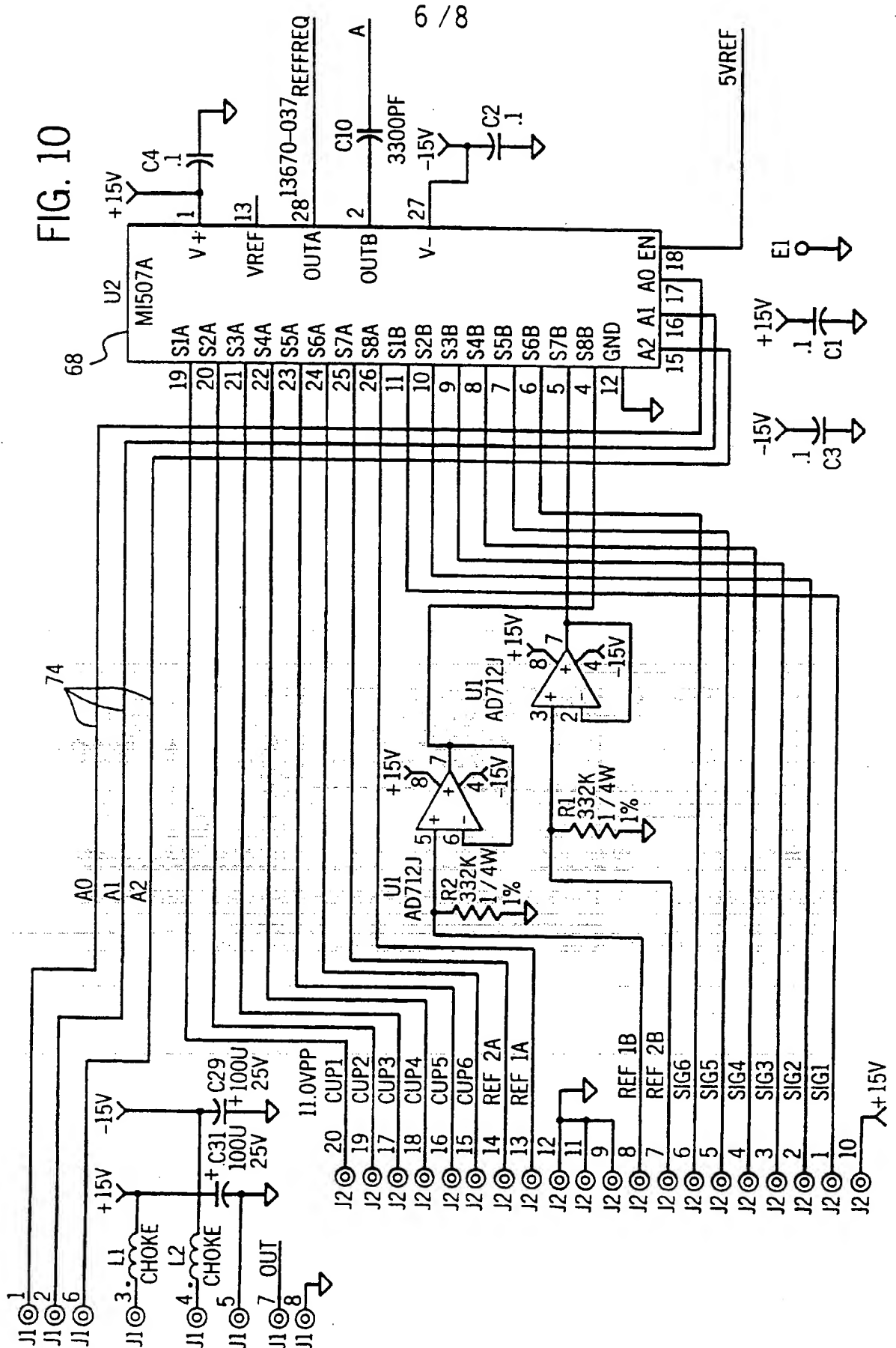
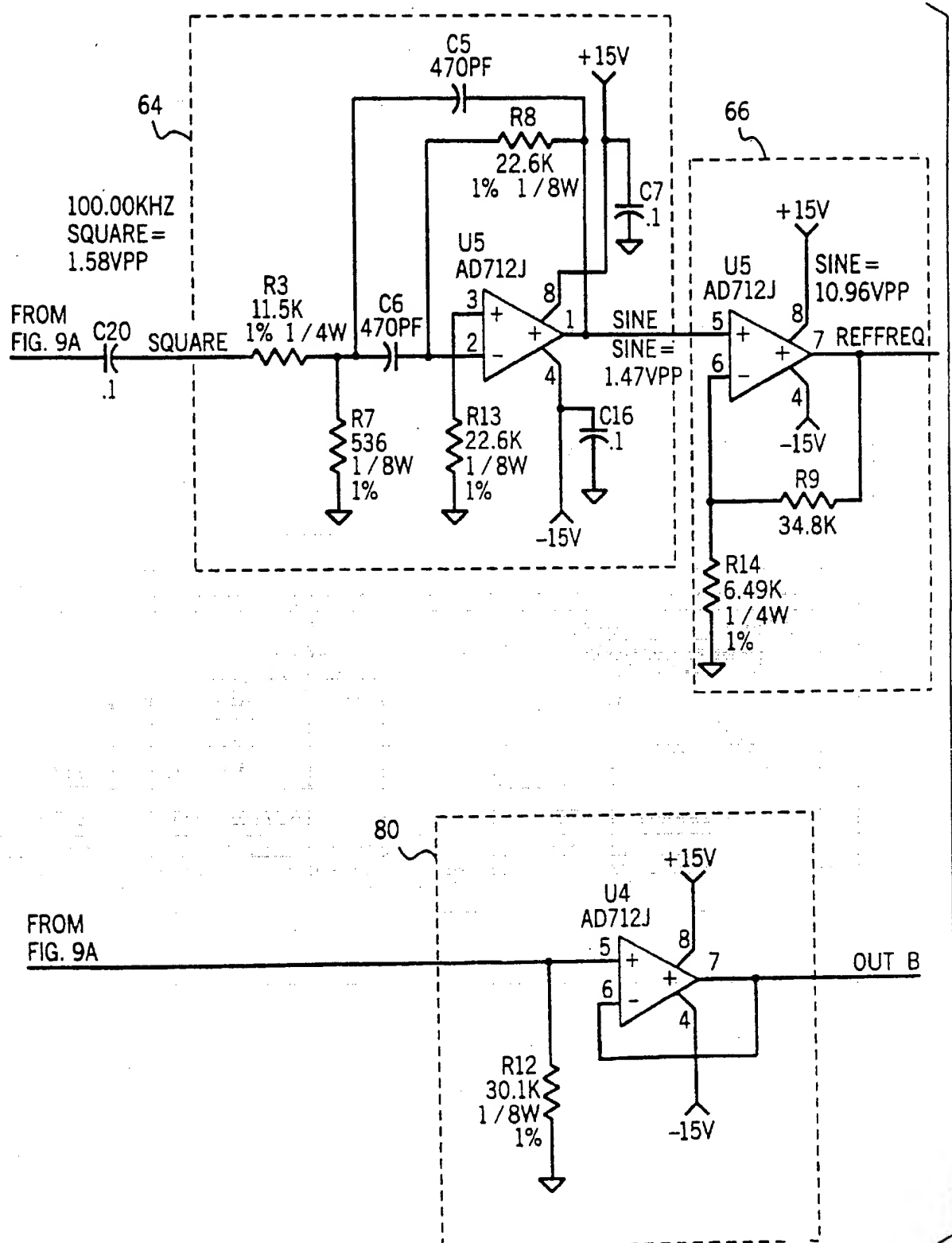


FIG. 10



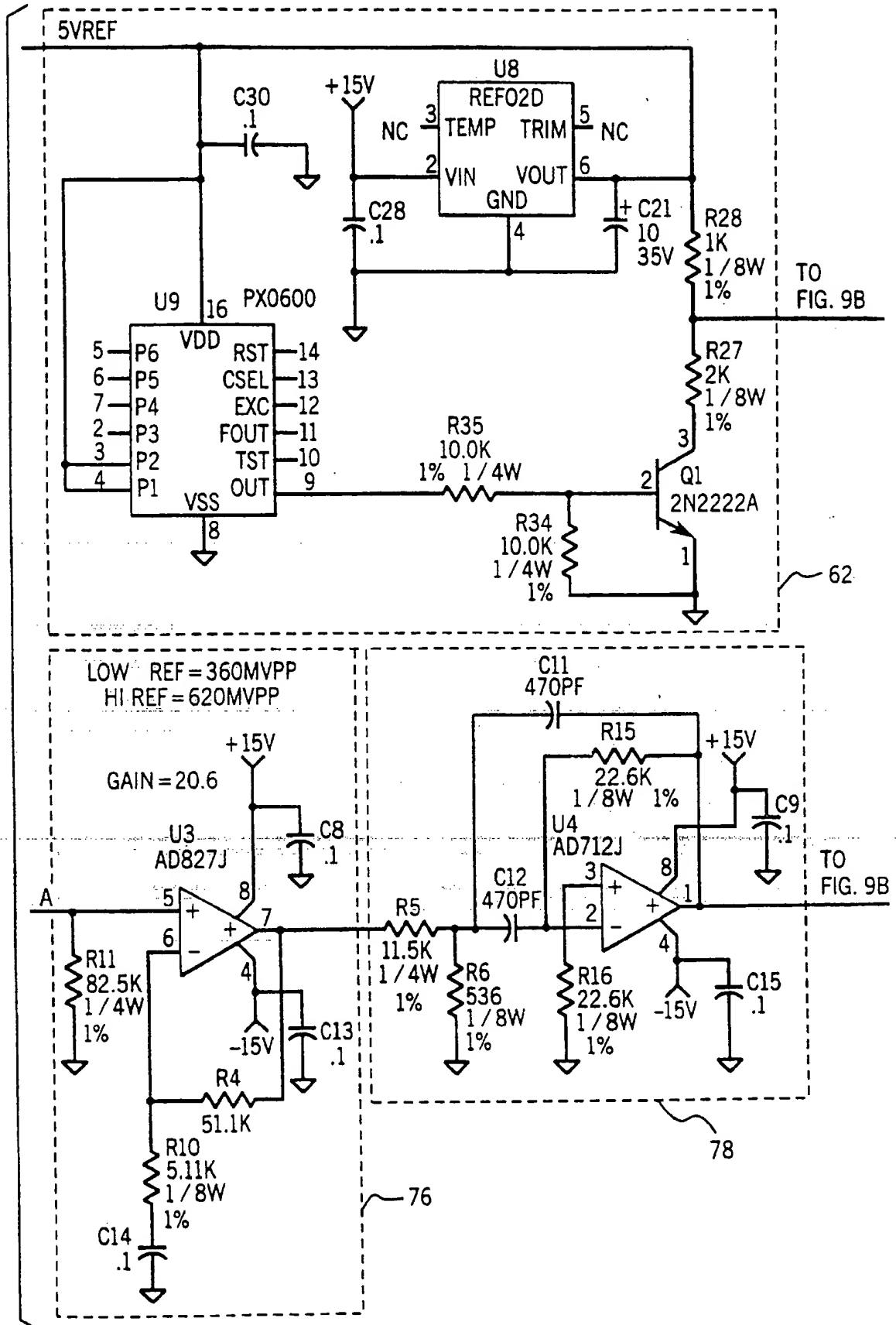
5 / 8

FIG. 9B



4 / 8

FIG. 9A



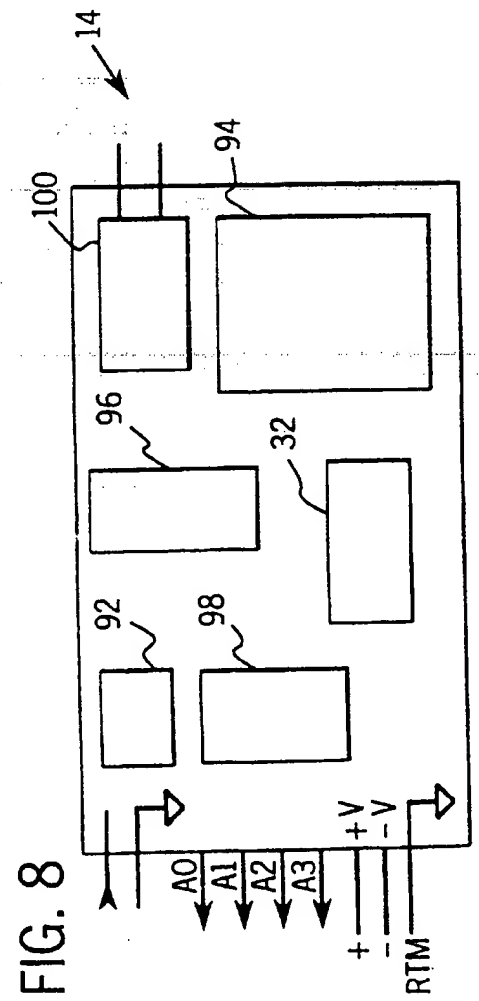
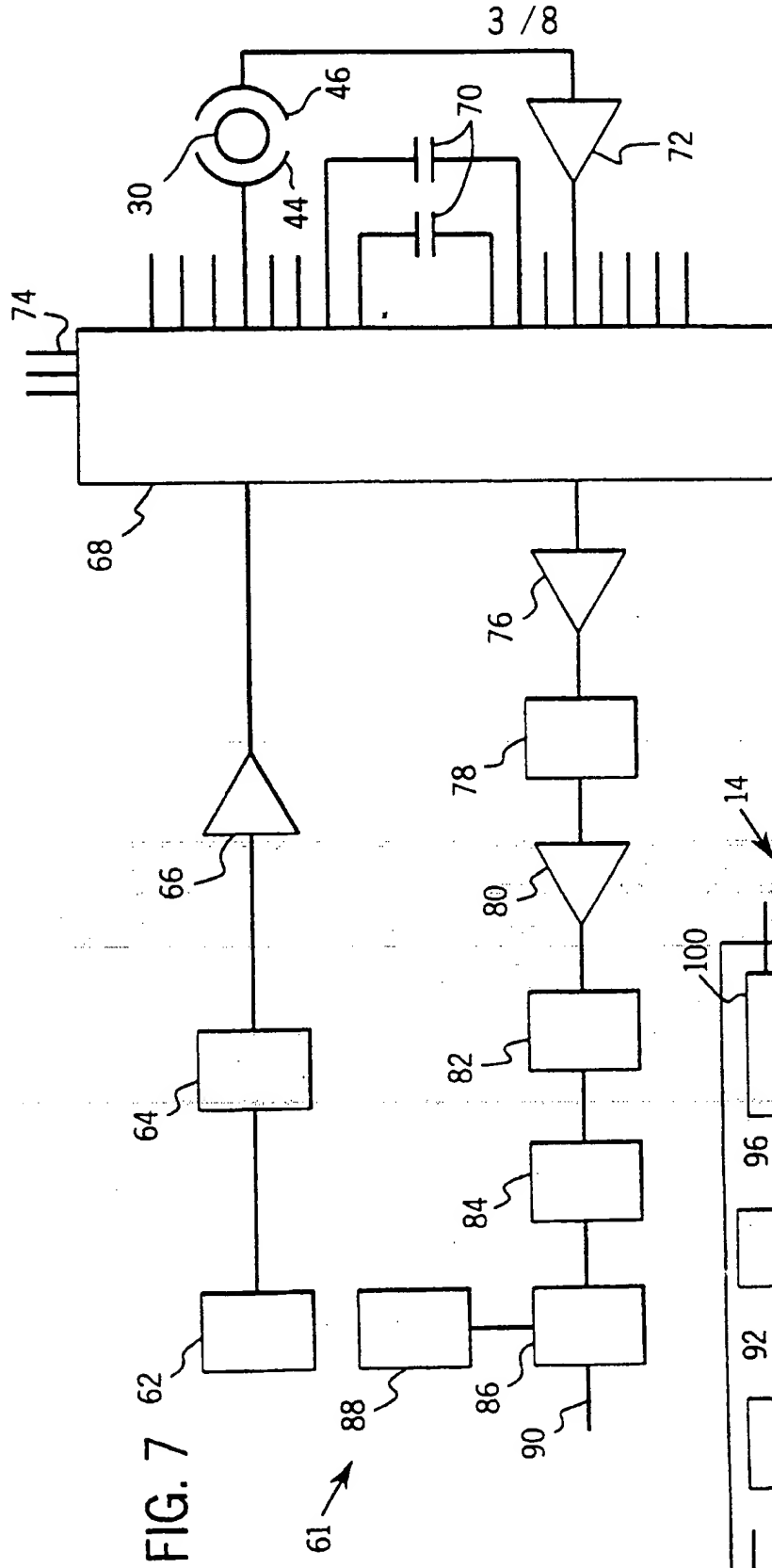


FIG. 4

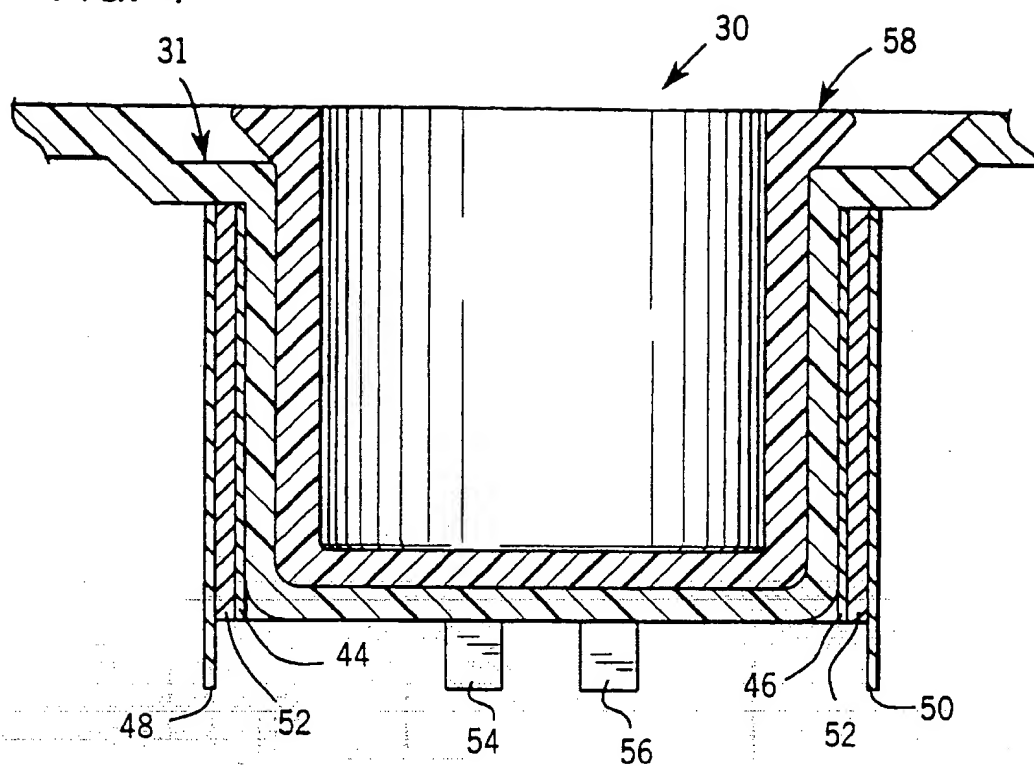


FIG. 5

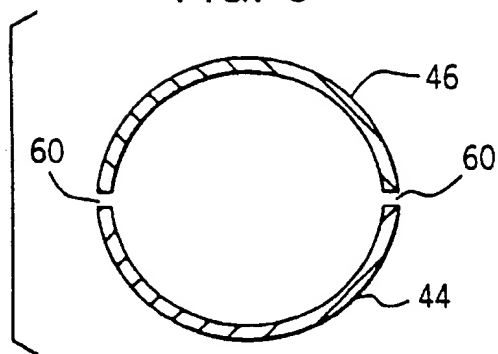
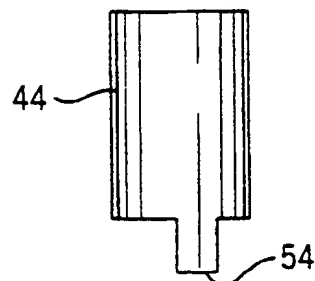


FIG. 6



1/8

FIG. 1

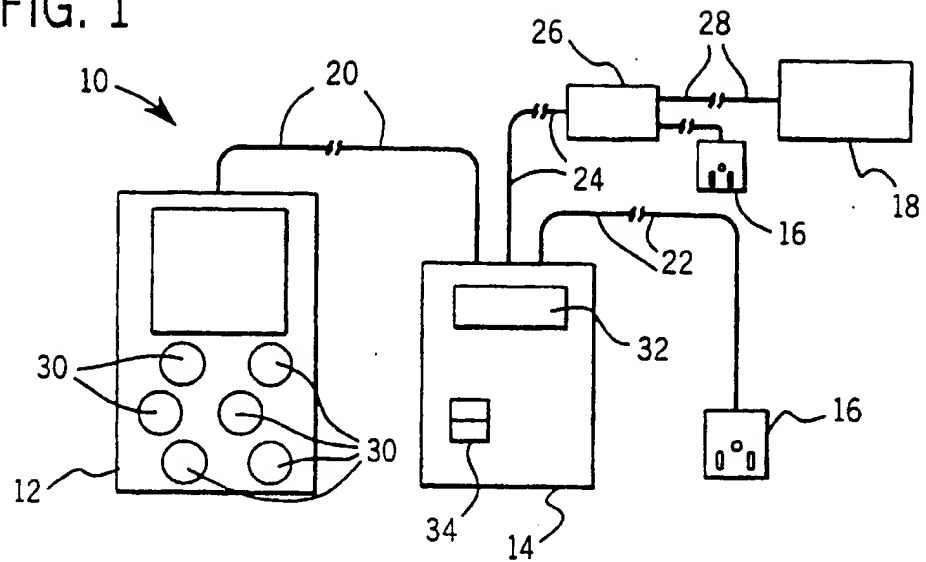


FIG. 2

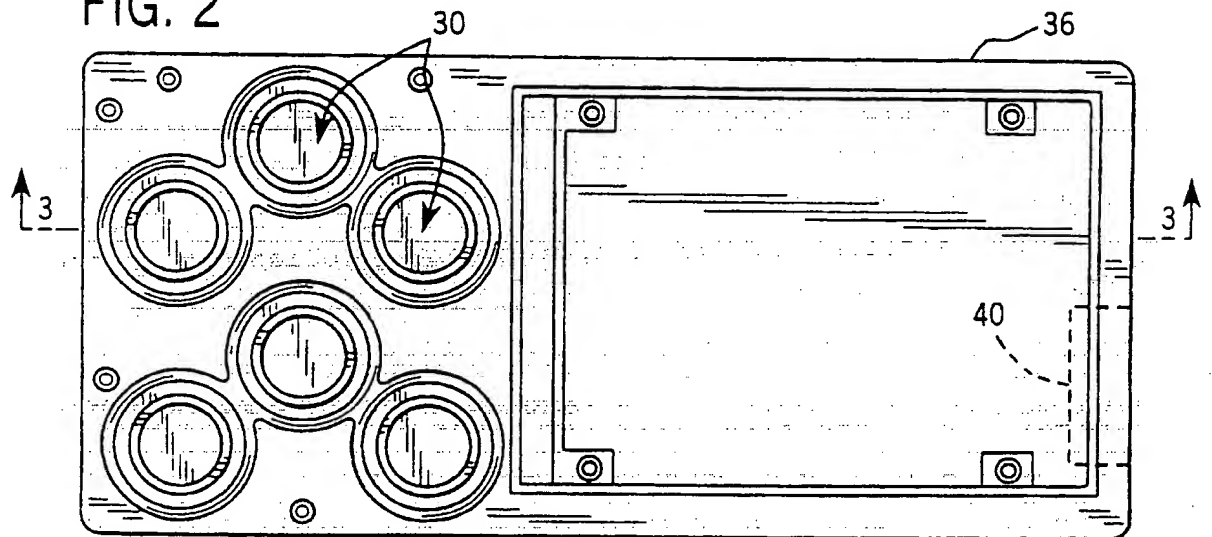
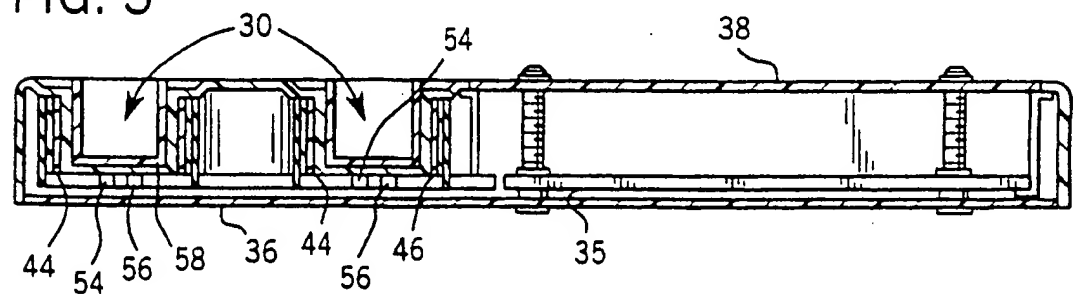


FIG. 3



11. A method for verifying a volume of a fluid, the method comprising the steps of:

- (a) placing a volume of fluid within a receptacle;
- (b) positioning a first conductor adjacent the receptacle
5 such that the first conductor does not contact the volume of fluid;
- (c) positioning a second conductor adjacent the receptacle such that the second conductor does not contact the volume of fluid or the first conductor;
- 10 (d) applying a first electrical signal to the first conductor; and
- (e) monitoring a second electrical signal generated in the second conductor responsive to the first electrical signal to verify the volume of the fluid in the receptacle.

15

12. An apparatus for verifying a volume of fluid comprising:

- (a) a receptacle for containing fluid;
- (b) a first conductor operatively associated with the
20 receptacle such that the first conductor does not contact the volume of the fluid;
- (c) a second conductor operatively associated with the receptacle offset from the first conductor such that the first conductor does not contact the volume of the fluid;
- 25 (d) a source of a first electrical signal electrically connected with the first conductor; and
- (e) a monitor electrically connected with the second conductor for detecting a second electrical signal created in the second conductor.

6. An apparatus as defined in claim 1 further comprising:
(f) a liner removably connectable with the receptacle.

7. An apparatus as defined in claim 1 further comprising:
5 (f) a computer electrically connected with at least one of
the first conductor and the second conductor.

8. A method for verifying a volume of fluid dispensed
from a nozzle, the method comprising the steps of:
10 (a) positioning a receptacle adjacent the nozzle such that
fluid dispensed from the nozzle enters the receptacle;
(b) applying a first electrical signal to a first
conductor operatively connected with the receptacle; and
(c) monitoring a second electrical signal created in a
15 second conductor operatively connected with the receptacle
responsive to the first electrical signal.

9. A method as defined in claim 8 further comprising the
steps of:
20 (d) predetermining a condition indicative of a desired
volume of fluid; and
(e) comparing the second electrical signal with the
condition to determine if the desired volume of fluid were in
the receptacle.

25 10. A method as defined in claim 8 wherein the monitoring
step (c) comprises
i. monitoring at least one of an amplitude of and a
voltage associated with the second electrical signal.

30

WHAT IS CLAIMED IS:

1. An apparatus for verifying a volume of fluid
5 comprising:
 - (a) a receptacle for containing fluid;
 - (b) a first conductor operatively associated with the receptacle;
 - (c) a second conductor operatively associated with the
10 receptacle offset from the first conductor;
 - (d) a source of a first electrical signal electrically connected with the first conductor; and
 - (e) a monitor electrically connected with the second
15 conductor for detecting a second electrical signal created in the second conductor.
2. An apparatus as defined in claim 1 further comprising:
 - (f) a feedback mechanism operatively connected with the
20 monitor such that the feedback mechanism provides feedback indicative of the second electrical signal.
3. An apparatus as defined in claim 1 further comprising:
 - (f) a third conductor electrically connected with at least
25 one of the first conductor and the second conductor to electromagnetically shield the at least one of the first conductor and the second conductor.
4. An apparatus as defined in claim 3 further comprising:
 - (g) an electrical insulator electrically disposed between
30 the third conductor and the at least one of the first conductor and the second conductor.
5. An apparatus as defined in claim 1 further comprising:
 - (f) a liner connectable with the receptacle.
35

52

```
CALL RCV
CALL GETNEWKEY(NEWKEY$)

IF DEBUG THEN PRINT sbuff$;
5 SCOUNT2 = VAL(RIGHT$(TIMES$, 2))
LOOP WHILE SCOUNT2 < SCOUNTEND

LFFLAG = 0

10 ENDREF = VAL((LEFT$(sbuff$, 7)))

DIFFREF = ABS((ENDREF - STARTREF))
IF DIFFREF < 15 THEN '15 FOR 5 SEC = 180 CNTS/MIN MAX DRIFT
PRINT #1, ESC$;
15 CALL RCV
CLS (2)
EXIT SUB
END IF

20 PRINT #1, ESC$;
CALL RCV

PRINT
PRINT "RETRY #"; Z; " OF "; NUMTRIES; " START CNT -"; STARTREF; " END CNT -";
25 ENDREF
NEXT Z

'FAILURE TO STABILIZE
PRINT
30 PRINT "****ERROR*** METER NOT STABILIZING WITHIN 1 MINUTE "
PRINT " Allow 10 minutes for tray warmup and check tray and cups."
PRINT
BEEP
IF RMX THEN CALL sendrmx(14) 'ESCAPE (HEX 'E')
35 SYSTEM

END SUB
```

51

LOOP WHILE (S AND &H80) > 0 'lo here - hi at remote

END SUB

5

SUB TESTREF

'*GET LOW REFERENCE*****

VIEW PRINT 4 TO 5

CLS (2)

10 PRINT " WAIT FOR TRAY STABILITY TEST ...";

PRINT #1, ESC\$;

CALL RCV

15 PRINT #1, "M6"

CALL RCV

CALL Delay(READDEL)

20 NUMTRIES = 200

FOR Z = 1 TO NUMTRIES

SCOUNT = (VAL(RIGHT\$(TIMES\$, 2))) + 1

25 IF SCOUNT > 59 THEN SCOUNT = SCOUNT - 60

SCOUNTEND = SCOUNT + 6

IF SCOUNTEND > 59 THEN SCOUNTEND = SCOUNTEND - 60

'SYNC TO NEXT SECOND

30 DO

SCOUNT2 = VAL(RIGHT\$(TIMES\$, 2))

LOOP WHILE SCOUNT2 = SCOUNT

35 VIEW PRINT 14 TO 23

LOCATE 23, 1

PRINT #1, "C"

40 LFFLAG = 1

DO

CALL RCV

CALL GETNEWKEY(NEWKEY\$)

45 STARTREF = VAL((LEFT\$(sbuff\$, 7)))

LOOP WHILE STARTREF = 0

DO

50

```

    IF NOT (A$ = CR$) THEN sbuff$ = sbuff$ + A$
    ' scout = 0

5  ' ELSE
    ' scout = scout + 1

    END IF

10  SCOUNT2 = VAL(RIGHT$(TIMES$, 2))
    IF SCOUNT = SCOUNT2 THEN
        PRINT
        PRINT "****ERROR*** METER NOT RESPONDING - Check cables and power"
15  PRINT
        BEEP
        IF RMX THEN CALL sendrmx(14)    'ESCAPE (HEX 'E')
        SYSTEM
    END IF

20

    'IF scout > 100 THEN EXIT DO
    IF LFFLAG > 0 AND A$ = LF$ THEN A$ = ">"
    LOOP WHILE NOT (A$ = ">")

25  x = LOC(1)
    IF x > 256 THEN PRINT "X>256"; x

    END SUB

30  SUB sendrmx (rmxsnd)
    x = rmxsnd
    OUT PPORTOUT%, (x OR &H10)    'set data
    OUT PPORTOUT%, x              'set READY ( low here - high at remote)

35  IF x = 14 THEN EXIT SUB

    DO
        S = INP(PPORTIN%)
40  LOOP WHILE (S AND &H80) = 0    'wait for ACK & echo (hi here - lo at remote)

        OUT PPORTOUT%, &H10        'reset ready - hi here - lo at remote

        cchar = ((S AND &H78) / 8)
45  IF DEBUG THEN PRINT "SENT TO RMX - "; cchar    ' print echo'ed char

    DO
        S = INP(PPORTIN%)          ' wait for ack to reset

```

```

END SUB

SUB getrmx
  rmxdatardy = 0
5  rmxrcv = 0 'clear last char
  S = INP(PPORTIN%) 'look for READY from remote

  IF (S AND &H80) > 0 THEN 'high here -low at remote
    cchar = ((S AND &H78) / 8) ' mask strobe and shift right 3x
10  IF DEBUG THEN PRINT "RCVD FROM RMX - "; cchar
    x = cchar
    GOSUB ackch
    rmxdatardy = -1
  END IF
15  rmxrcv = cchar
  EXIT SUB

ackch:
20  OUT PPORTOUT%, (x OR &H10)
  OUT PPORTOUT%, x

  DO
    GETNEWKEY (NEWKEY$)
25  S = INP(PPORTIN%)
    LOOP WHILE (S AND &H80) > 0

    OUT PPORTOUT%, &H10
    RETURN
30  END SUB

SUB RCV
.....RECEIVE DATA FROM METER.....
35  SCOUNT = (VAL(RIGHT$(TIMES$, 2))) + 3
  IF SCOUNT > 59 THEN SCOUNT = SCOUNT - 60

  A$ = ""
  sbuff$ = ""
40  DO

  IF LOC(1) > 0 THEN
    ALAST$ = A$
45  A$ = INPUT$(1, #1)

  ' PRINT a$;
  ' PRINT VAL(A$);
  ' IF ((ECHO$ = (CR$)) AND A$ = CHR$(6)) THEN SBUFF$ = SBUFF$ + CR$: EXIT DO

```

```
PRINT "      WAIT WHILE LOW REFERENCE READS ARE OBTAINED";

PRINT #1, ESC$;
CALL RCV
5  PRINT #1, "M6"
   CALL RCV

VIEW PRINT 14 TO 23
10 LOCATE 23, 1
   PRINT #1, "C"

LFFLAG = 1
CALL RCV
15 FOR i = 1 TO 5
   CALL RCV
   IF (i > 1) AND DEBUG THEN PRINT sbuff$;
NEXT
20 LFFLAG = 0

LOWREF$ = LEFT$(sbuff$, 7)

25 '*GET HIGH REFERENCE.....
   VIEW PRINT 3 TO 4
   CLS (2)
   PRINT
   PRINT "      WAIT WHILE HIGH REFERENCE READS ARE OBTAINED";
30 PRINT #1, ESC$;
   CALL RCV

   PRINT #1, "M7"
35 CALL RCV

VIEW PRINT 14 TO 23
LOCATE 23, 1
PRINT #1, "C"
40 LFFLAG = 1
   CALL RCV

FOR i = 1 TO 5
45 CALL RCV
   IF (i > 1) AND DEBUG THEN PRINT sbuff$;
NEXT
HIGHREF$ = LEFT$(sbuff$, 7)
LFFLAG = 0
```

```

CASE 4
PRINT "          | X          |"
PRINT "          | X X      |"
PRINT "          | 3          |"
5 PRINT "          | X X      |"

CASE 5
PRINT "          | X          |"
PRINT "        B | X 6          |"
10 PRINT "          | X          |"
PRINT "        A | X 5          |"

CASE 6
PRINT "          | X          |"
15 PRINT "          | X X      |"
PRINT "          | X          |"
PRINT "          | X 5          |"

END SELECT
20 PRINT "          -----"
PRINT
IF DEBUG THEN
PRINT " RAW-A MX ADJ-A LAST RD VOLUME   RAW-B MX ADJ-B LAST RD
VOLUME";
25 ELSE
PRINT " Dispense No.   Sub-A   Sub-B"
END IF
END SUB

30 SUB GETNEWKEY (NEWKEY$)
NEWKEY$ = UCASE$(INKEY$)
IF NEWKEY$ = ESC$ THEN
CLS
PRINT
35 PRINT "RUN ABORTED BY USER"
.....RMX Parallel .....
IF RMX THEN
CALL sendrmx(14) 'ESCAPE (HEX 'E')
END IF
40 .....RMX Parallel .....
SYSTEM
END IF
END SUB

45 SUB GETREFS (LOWREF$, HIGHREF$)
'GET LOW REFERENCE.....
VIEW PRINT 3 TO 4
CLS (2)
PRINT

```

46

```

DIM INARY%(7), OUTARY%(7)      'Define input and output
                                'arrays for INT86.

' Define register-array indices to
5 ' make program easier to understand.
CONST ax = 0, bx = 1, cx = 2, dx = 3, bp = 4, si = 5, di = 6, FL = 7

10 INARY%(ax) = &H8600           'DOS function to WAIT SERVICE
    INARY%(cx) = counts / 800    'DOS HIGH ORDER WAIT
    INARY%(dx) = &H61A8         'DOS LOW ORDER WAIT
    x = INP(&H61)

CALL INT86OLD(&H15, INARY%(), OUTARY%())
15 'Perform the delay

END SUB

SUB DISPTRAY (chan)
20 VIEW PRINT 5 TO 14
CLS (2)
PRINT
PRINT "
SELECT CASE chan
25
CASE 0
PRINT "
PRINT "      | 4      |"
PRINT "      B | 2 6  |"
PRINT "      | 3      |"
30 PRINT "      A | 1 5  |"

CASE 1
PRINT "
PRINT "      | X      |"
PRINT "      B | 2 X    |"
35 PRINT "      | X      |"
PRINT "      A | 1 X    |"

CASE 2
PRINT "
PRINT "      | X      |"
40 PRINT "      | X X     |"
PRINT "      | X      |"
PRINT "      | 1 X     |"

CASE 3
45 PRINT "      B | 4      |"
PRINT "      | X X     |"
PRINT "      A | 3      |"
PRINT "      | X X     |"

```

45

```
    idcnt = idcnt - 1
    LOCATE CSRLIN, (POS(0) - 1)
    PRINT " ";

5    LOCATE CSRLIN, (POS(0) - 1)
    NEWSLOPE$ = LEFT$(NEWSLOPE$, (LEN(NEWSLOPE$) - 1))
    END IF

    ELSE
10    IF idcnt = 5 THEN
        idcnt = idcnt - 1
        LOCATE CSRLIN, (POS(0) - 1)
        NEWSLOPE$ = LEFT$(NEWSLOPE$, (LEN(NEWSLOPE$) - 1))
    END IF

15    NEWSLOPE$ = NEWSLOPE$ + NEWKEY$
        idcnt = idcnt + 1
        PRINT NEWKEY$;
    END IF

20    LOOP WHILE idcnt < 6

        SLOPEVAL = VAL(NEWSLOPE$)
        LOCATE CSRLIN, 1
25    PRINT SPACE$(79);
        LOCATE CSRLIN, 1
        RETURN

    SUB BENCHDISP
30
        REM Start Pump by writing 1H to Parallel Port
        OUT PPORTOUT%, &H1
        WAIT PPORTIN%, &H20, &H20
        WAIT PPORTIN%, &H20
35    REM Wait for 300ms
        CALL Delay(3300)
        OUT PPORTOUT%, &H0
        REM Stop Pump by writing 0H to Parallel Port
        OUT PPORTOUT%, &H0
40
    END SUB

    SUB Delay (counts)
        'x = 0
45    'WHILE x < counts
        'x = x + 1

    'WEND
```

```
    ident = 4
    EXIT DO
END IF

5  IF NEWKEY$ = BS$ THEN
    IF ident > 0 THEN
        ident = ident - 1
        LOCATE CSRLIN, (POS(0) - 1)
        PRINT " ";
10     LOCATE CSRLIN, (POS(0) - 1)
        MACHINEID$ = LEFT$(MACHINEID$, (LEN(MACHINEID$) - 1))
        END IF

15    ELSE
        IF ident = 3 THEN
            ident = ident - 1
            LOCATE CSRLIN, (POS(0) - 1)
            MACHINEID$ = LEFT$(MACHINEID$, (LEN(MACHINEID$) - 1))
20        END IF

        MACHINEID$ = MACHINEID$ + NEWKEY$
        ident = ident + 1
        PRINT NEWKEY$;
25    END IF

    LOOP WHILE ident < 5
    RETURN

30  'GETMACHINEID:

    GETSLOPE:
    NEWSLOPE$ = ""
    ident = 0
35  PRINT
    PRINT "ENTER CORRECT VALUE FOR THIS WELL IN uL (xx.xx) > ";
    DO
    DO
        CALL GETNEWKEY(NEWKEY$)
40    LOOP WHILE NEWKEY$ = ""

    IF NEWKEY$ = CR$ THEN
        IF ident < 2 THEN GOTO GETSLOPE
        ident = 5
45    EXIT DO
    END IF

    IF NEWKEY$ = BS$ THEN
        IF ident > 0 THEN
```

```

RETURN

noslope:
5  PRINT "ERROR-SLOPE.CAL NOT FOUND"
  PRINT "RUN RFCAL PRIOR TO OPERATION"
  SYSTEM

  .....machine   id   code.....
10  NOMACHINEID:
    GOSUB GETMACHINEID
    GOTO continueinit

    newmachineid:
15  GOSUB GETMACHINEID
    GOSUB SAVESLOPES:
    GOTO continueinit

    SAVESLOPES:
20  PRINT #1, ESC$;
    CALL RCV
    FOR i = 1 TO 6
      PRINT #1, "S" + LTRIM$(RTRIM$(STR$(i))) + LTRIM$(RTRIM$(STR$(slope(i)))) +
25  CR$
    CALL RCV
    SLEEP (1)
  NEXT i
  RETURN

30  GETMACHINEID:
    idcnt = 0
    MACHINEID$ = ""

35  VIEW:PRINT 1 TO 2
    LOCATE 2, 1
    PRINT SPACES$(79);

    LOCATE 2, 1
40  PRINT "Enter PRISM ID NUMBER (001 - 999) > ";
    DO
    DO
      CALL GETNEWKEY(NEWKEY$)
      LOOP WHILE NEWKEY$ = ""

45  IF NEWKEY$ = CR$ THEN
    IF idcnt = 0 THEN GOTO GETMACHINEID
    IF idcnt = 1 THEN MACHINEID$ = "00" + MACHINEID$
    IF idcnt = 2 THEN MACHINEID$ = "0" + MACHINEID$

```

42

```

chnum = VAL(MID$(S$, 9, 1))
diffa = oldchana / 32 - S
.....

5  IF DEBUG THEN
    PRINT USING "##### # #####.## #####.##"; chana; chnum; S; diffa;
    IF j > 0 THEN PRINT USING "#####.## "; (ABS((rdata(chan, j - 1, 1) - chana) /
32)) * 50 * 32 / slope(chan); ELSE PRINT " ";
ELSE
10  IF j > 0 THEN PRINT USING " #####.## uL"; (ABS((rdata(chan, j - 1, 1) - chana) /
32)) * 50 * 32 / slope(chan);
END IF
.....

15  SELECT CASE chan + 1
    CASE 1: PRINT #1, "M4"
    CASE 2: PRINT #1, "M1"
    CASE 3: PRINT #1, "M3"
    CASE 4: PRINT #1, "M0"
20  CASE 5: PRINT #1, "M5"
    CASE 6: PRINT #1, "M2"
END SELECT
CALL RCV
CALL Delay(READDEL) 'delay for apres mux

25  PRINT #1, "R"
CALL RCV
.....

30  S$ = MID$(sbuff$, 3, 10) + " "
    S = VAL(LEFT$(S$, 8)) / 32

    oldchanb = chanb
    chanb = VAL(LEFT$(S$, 7))
35  chnum = VAL(MID$(S$, 9, 1))
    diffb = oldchanb / 32 - S
    .....

    IF DEBUG THEN
40  PRINT USING "##### # #####.## #####.##"; chanb; chnum; S; diffb;
    IF j > 0 THEN PRINT USING "#####.## "; (ABS((rdata(chan + 1, j - 1, 1) - chanb) /
32)) * 50 * 32 / slope(chan + 1); ELSE PRINT " ";
    PRINT
ELSE
45  IF j > 0 THEN PRINT USING " #####.## uL "; (ABS((rdata(chan + 1, j - 1, 1) - chanb)
/ 32)) * 50 * 32 / slope(chan + 1);
    PRINT
END IF

```

```

    END IF

    DISSTART = 1
    DISEND = ENDCNT
5   FOR i = DISSTART TO DISEND
        rarray(i, 4) = rarray(i, 2) * rarray(i, 2)
    NEXT

10  GOSUB CALCULATE

    GOSUB printit

    CLOSE #2

15  RETURN

    DBLREAD:
    *****inner read loop

20  VIEW PRINT 14 TO 23

    IF DEBUG THEN
        LOCATE 23, 1
25  ELSE
        LOCATE (14 + j), 1
        IF j > 0 THEN PRINT USING "    ##    "; j;
    END IF

30  SELECT CASE chan
        CASE 1: PRINT #1, "M4"
        CASE 2: PRINT #1, "M1"
        CASE 3: PRINT #1, "M3"
        CASE 4: PRINT #1, "M0"
35  CASE 5: PRINT #1, "M5"
        CASE 6: PRINT #1, "M2"
    END SELECT

    CALL RCV

40  CALL Delay(READDEL) 'delay for apres mux

    PRINT #1, "R"
    CALL RCV
    *****

45  S$ = MID$(sbuff$, 3, 10) + " "
    S = VAL(LEFT$(S$, 8)) / 32

    oldchana = chana
    chana = VAL(LEFT$(S$, 7))

```

40

```

        END IF
        END IF
        END IF
5      END IF

      PRINT " ";

      RETURN
10     .....

      ErrorRecover:
      PRINT "ERROR # -";
15     PRINT ERR
      STOP

      .....
      ' START OF CALCULATIONS
20     .....

      docalc:

      SCOUNT = 0
25     skip = 0

      OPEN logfilename$ FOR APPEND AS #2
      PRINT #2,
      PRINT #2, "          PRISM RF VOLUME VALIDATION "
30     PRINT #2, "PRISM " + MACHINEIDS;
      PRINT #2, " " + DATE$ + " " + TIME$
      IF RMX THEN PRINT #2, " Channel "; channelnumber; " Pump " +
      PUMPLIST$(PUMPNUMBER)
      PRINT #2, " Cup number " + chan$;
35     IF chan$ = "1" OR chan$ = "3" OR chan$ = "5" THEN PRINT #2, " Sub-A" ELSE PRINT #2,
      " Sub-B"

      IF DEBUG THEN
      PRINT #2, "INIT LOW REF "; ref(chan, 1, 1)
40     PRINT #2, "INIT HIGH REF "; ref(chan, 2, 1)

      PRINT #2, "FINAL LOW REF "; ref(chan, 1, 2)
      PRINT #2, "FINAL HIGH REF "; ref(chan, 2, 2)

45     FOR A = 0 TO ENDCNT
      PRINT #2, A, ;
      PRINT #2, USING " #####.#"; rarray(A, 1);
      PRINT #2, USING " #####.#"; rarray(A, 2)
      NEXT A

```

```
      PRINT #2, " MEAN VOLUME > 52.5 uL "
    END IF
5    IF CV > 2 THEN
      PRINT " CV > 2% "
      PRINT #2, " CV > 2% "
    ELSE
      PRINT " CV > 1.5%"
10     PRINT #2, " CV > 1.5%"
    END IF

    END IF
    END IF
15  ELSE
    *****HERE FOR SAMPLE MANAGER
    IF PASS THEN
      PRINT " *PASS* ": PRINT #2, " PASS "
    END IF
20  IF NOT PASS THEN
      PRINT "****FAIL-"; : PRINT #2, " FAIL ";

      IF (vol < 47.5) THEN
25      PRINT "VOL < 47.5 uL";
      PRINT #2, " MEAN VOLUME < 47.5 uL "

      IF (vol < 45.5) THEN
        PRINT "VOL < 45.5 uL";
30      PRINT #2, " MEAN VOLUME < 45.5 uL "

      ELSE
        IF (vol > 52.5) THEN
          PRINT "VOL > 52.5 uL";
35      PRINT #2, " MEAN VOLUME > 52.5 uL "

          IF (vol > 54.5) THEN
            PRINT "VOL > 54.5 uL";
            PRINT #2, " MEAN VOLUME > 54.5 uL "
40          END IF

          IF CV > 9 THEN
            PRINT " CV > 9% "
45      PRINT #2, " CV > 9% "
          ELSE
            PRINT " CV > 1.5%"
            PRINT #2, " CV > 1.5%"
          END IF
        END IF
      END IF
    END IF
```

END IF

vol = mean * 50 / slopecal
CV = (stdev / mean) * 100

5

PASS = 0

STEP 17

```

10 IF NOT PUMPNUMBER = 9 THEN
    IF (vol >= 48) AND (vol <= 52) AND (CV <= 2) THEN PASS = -1
    ' IF (vol >= 48.5) AND (vol <= 51.5) AND (CV <= 2) THEN PASS = -1
    ' IF (vol >= 48!) AND (vol <= 52!) AND (CV <= 1.5) THEN PASS = -1
    ' IF (vol >= 47.5) AND (vol <= 48!) AND (CV <= (1 - (48 - vol) * 2)) THEN PASS = -1
15 ' IF (vol >= 52!) AND (vol <= 52.5) AND (CV <= (1 - (vol - 52!) * 2)) THEN PASS = -1
    ELSE
    *****HERE FOR SAMPLE MANAGER
    IF (vol >= 47.5) AND (vol <= 52.5) THEN PASS = -1
    ' IF (vol >= 45.5) AND (vol <= 54.5) AND (CV <= 9) THEN PASS = -1
20 ' IF (vol >= 48!) AND (vol <= 52!) AND (CV <= 1.5) THEN PASS = -1
    ' IF (vol >= 47.5) AND (vol <= 48!) AND (CV <= (1 - (48 - vol) * 2)) THEN PASS = -1
    ' IF (vol >= 52!) AND (vol <= 52.5) AND (CV <= (1 - (vol - 52!) * 2)) THEN PASS = -1

    END IF

25 IF RMX THEN
    IF NOT PUMPNUMBER = 9 THEN
    IF PASS THEN
    PRINT " *PASS* ": PRINT #2, " PASS."
30 END IF

    IF NOT PASS THEN
    PRINT "****FAIL-": PRINT #2, " FAIL-";

35 IF (vol < 48) THEN
    PRINT "VOL < 48 uL";
    PRINT #2, " MEAN VOLUME < 48 uL "

    IF (vol < 47.5) THEN
40 PRINT "VOL < 47.5 uL";
    PRINT #2, " MEAN VOLUME < 47.5 uL "

    ELSE
    IF (vol > 52) THEN
45 PRINT "VOL > 52 uL";
    PRINT #2, " MEAN VOLUME > 52 uL "

    IF (vol > 52.5) THEN
    PRINT "VOL > 52.5 uL";
  
```

```

NEXT
runmean = mean
sumsq = runmean * runmean

5  mean = mean / meannum

stdev = SQR((meannum * meansq - sumsq) / (meannum * meannum))

FOR i = (DISSTART) TO (DISEND)
10  rarray(i, 3) = -(mean - rarray(i, 2))
NEXT

RETURN

15  printit:

STEP 15
FOR i = DISSTART TO DISEND
IF DEBUG THEN
20  PRINT USING " #####.##   #####.##   ###.## uL"; rarray(i, 1);
    rarray(i, 2); rarray(i, 3); rarray(i, 2) * 50 / slopecal
    PRINT #2, USING "#####.##,#####.##,###.##,uL"; rarray(i, 1);
    rarray(i, 2); rarray(i, 3); rarray(i, 2) * 50 / slopecal
ELSE
25  PRINT USING "      ###.## uL"; rarray(i, 2) * 50 / slopecal
    PRINT #2, USING "###.##,uL"; rarray(i, 2) * 50 / slopecal
END IF
NEXT

30  STEP 16
IF DEBUG THEN
    PRINT USING " Mean = #####.## counts ###.## uL PerCent CV =###.##%"; mean;
    mean * 50 / slopecal; (stdev / mean) * 100
    PRINT USING " StDev = ###.## counts ###.## uL No. of Reads =## "; stdev; stdev
35  * 50 / slopecal; meannum;
    PRINT #2, USING "Mean =,#####.##,counts,###.##,uL,PerCent,CV=,###.##,%";
    mean; mean * 50 / slopecal; (stdev / mean) * 100
    PRINT #2, USING "StDev=,###.##,counts,###.##,uL,Number-Reads=,##"; stdev;
    stdev * 50 / slopecal; meannum;
40  ELSE
    PRINT USING " Mean = ###.## uL PerCent CV =###.##%"; mean * 50 / slopecal;
    (stdev / mean) * 100
    PRINT USING " StDev = ###.## uL No. of Reads =## "; stdev * 50 / slopecal;
    meannum;
45  PRINT #2, USING "Mean =,#####.##,uL,PerCent-CV=,###.##,%"; mean * 50 / slopecal;
    (stdev / mean) * 100
    PRINT #2, USING "StDev=,###.##,uL,Number-Reads=,##"; stdev * 50 / slopecal;
    meannum;

```

36

```

END IF
FOR j = 0 TO ENDCNT
  IF j > 0 THEN rarray(j, 2) = rdata(chan + 1, j, 3) ELSE rarray(j, 2) = 0
  rarray(j, 1) = rdata(chan + 1, j, 1)
5  NEXT
  chan$ = chanb$
  GOSUB docalc
  PASSB = PASS

10 IF NOT RMX THEN
  IF traycal THEN
    GOSUB GETSLOPE
    slope(chan + 1) = (slope(chan + 1) / VAL(NEWSLOPE$)) * vol '???'
    GOSUB SAVESLOPES
15  END IF

  END IF

  *****end of system well-pair loop
20  CLOSE #1
  *****RMX    Parallel *****

  IF PASSA AND PASSB THEN RESULT = 1
  IF NOT PASSA AND NOT PASSB THEN RESULT = 0
25  IF PASSA AND NOT PASSB THEN RESULT = 2
  IF NOT PASSA AND PASSB THEN RESULT = 3
  IF RMX THEN
    CALL sendrmx(RESULT)
  END IF
30  *****RMX    Parallel *****

  LOCATE 24, 1
  SYSTEM

35  errorhandler:

  PRINT USING "ERROR ### - PROGRAM HALTED ****"; ERR
  STOP

40  CALCULATE:
  mean = 0
  meansq = 0

  meannum = DISEND - DISSTART + 1

45  STEP 14
  FOR i = (DISSTART) TO (DISEND)
    mean = mean + rarray(i, 2)
    meansq = meansq + rarray(i, 4)

```

```

    PRINT NEWKEY$
    END IF

    CLS
5   IF RMX THEN
    PRINT " PRISM " + MACHINEID$ + "   File-" + logfilename$ + "   Channel ";
    channelnumber; "   " + PUMPLIST$(PUMPNUMBER) + " Pump   " + DATE$
    ELSE
    PRINT " PRISM " + MACHINEID$ + "           File-" + logfilename$ + "           " +
10  DATE$
    END IF

    slopecal = slope(chan)
    PRINT
15  PRINT "CUP " + chana$;
    IF DEBUG THEN
    PRINT USING " A-CNTS DIFF  VAR FROM MEAN  VOLUME W/SLOPE =#####.#
    COUNTS/50 uL"; slopecal
    ELSE
20  PRINT "      Sub-A VOL"
    END IF

    FOR j = 0 TO ENDONT

25  STEP 13
    IF j > 0 THEN rarray(j, 2) = rdata(chan, j, 3) ELSE rarray(j, 2) = 0
    rarray(j, 1) = rdata(chan, j, 1)
    NEXT
    chan$ = chana$
30  GOSUB docalc
    PASSA = PASS
    .....

    IF traycal THEN
35  GOSUB GETSLOPE
    slope(chan) = (slope(chan) / VAL(NEWSLOPE$)) * vol '???'

    END IF
    .....

40

    PRINT
    slopecal = slope(chan + 1)
    PRINT "CUP " + chanb$;
45  IF DEBUG THEN
    PRINT USING " B-CNTS DIFF  VAR FROM MEAN  VOLUME W/SLOPE =#####.#
    COUNTS/50 uL"; slopecal
    ELSE
    PRINT "      Sub-B VOL"

```

```

.....RMX    Parallel .....
END IF
.....RMX    Parallel .....
5  .....    BENCH .....
    IF BENCH THEN
        CALL BENCHDISP
    END IF
10 .....    BENCH .....

STEP 11
NEXT
'end of outer read loop
15 .....GET  REFERENCE  READINGS.....
    VIEW PRINT 3 TO 5
    CLS (2)

STEP 12
20 CALL GETREFS(startlow$, starthigh$)
    ref(chan, 1, 2) = VAL(LEFT$(startlow$, 7))
    ref(chan, 2, 2) = VAL(LEFT$(starthigh$, 7))

    .....END OF CHANNEL DATA COLLECTION
25
    VIEW PRINT 1 TO 25
    CLS

30 FOR j = 0 TO ENDCNT
    IF j > 0 THEN rdata(chan, j, 3) = rdata(chan, j, 1) - rdata(chan, j - 1, 1)
    IF j > 0 THEN rdata(chan + 1, j, 3) = rdata(chan + 1, j, 1) - rdata(chan + 1, j - 1, 1)
    NEXT

35 IF DEBUG THEN
    PRINT "INIT LOW REF = "; ref(chan, 1, 1); "INIT HIGH REF = "; ref(chan, 2, 1)
    PRINT "FINAL LOW REF = "; ref(chan, 1, 2); "FINAL HIGH REF = "; ref(chan, 2, 2)
    END IF

40 ***** START OF CALCULATIONS

    IF NOT RMX THEN
        traycal = 0
        PRINT "IS THIS A TRAY CALIBRATION RUN (Y/N) >";
45 DO
        CALL GETNEWKEY(NEWKEY$)
        LOOP WHILE NEWKEY$ = ""
        NEWKEY$ = UCASE$(NEWKEY$)
        IF (NEWKEY$ = "Y") THEN traycal = -1

```

*****LOOK FOR DISPENSE
DO

5 **STEP 8**

GOSUB DBLREAD
CALL GETNEWKEY(NEWKEY\$)
LOOP WHILE ABS(diffa) < DIFF AND ABS(diffb) < DIFF

10 END IF

DIFFCNT = 0

*****LOOK FOR SETTLING AFTER DISPENSE

15 DO
GOSUB DBLREAD 'get a,b adc values
IF j = 0 THEN GOSUB DBLREAD
IF j = 0 THEN GOSUB DBLREAD: EXIT DO

20 **STEP 9**

IF ABS(diffa) < DIFF AND ABS(diffb) < DIFF THEN DIFFCNT = DIFFCNT + 1 ELSE DIFFCNT = 0

IF DIFFCNT = DIFFREPS THEN EXIT DO

CALL GETNEWKEY(NEWKEY\$)

25 LOOP WHILE NEWKEY\$ = ""

*****SAVE READ

STEP 10

30 rdata(chan, j, 1) = chana
rdata(chan + 1, j, 1) = chanb

'PRINT CHR\$(7); BELL

BEEP

35 PRINT

CALL Delay(500)

DO

LOOP WHILE INKEY\$ <> "" 'WAIT FOR ANY ECHO

40 *****RMX Parallel *****

IF RMX THEN

CALL sendrmx(1) 'valid read

*****RMX Parallel *****

45 DO

CALL getrmx

LOOP WHILE rmxcv < 3 OR rmxcv > 4 'look for dispense start

IF DEBUG THEN PRINT " Received PRISM Start Dispense Command"

rmxprime = -1

32

```

CALL GETNEWKEY(NEWKEY$)
IF (ABS(diffa) > PRIMESTART) OR (ABS(diffb) > PRIMESTART) THEN DIFFCNT = DIFFCNT
+ 1 ELSE DIFFCNT = 0
' DIFFCNT = 5
5 ..... BENCH .....
IF BENCH THEN
  CALL BENCHDISP
END IF
10 ..... BENCH .....

LOOP WHILE DIFFCNT < PRSTARTCNT

DIFFCNT = 0
15 .....LOOK FOR SETTLING AFTER DISPENSE
DO
  GOSUB DBLREAD 'get a,b adc values

20 STEP 6
  IF ABS(diffa) < PRIMEDIFF AND ABS(diffb) < PRIMEDIFF THEN DIFFCNT = DIFFCNT + 1
  ELSE DIFFCNT = 0
  IF DIFFCNT > PRIMEREPS THEN EXIT DO
  CALL GETNEWKEY(NEWKEY$)
25 LOOP WHILE NEWKEY$ = ""

.....GET REFERENCE READINGS.....
PRINT #1, ESC$;
CALL RCV

30 STEP 7
  CALL GETREFS(startlow$, starthigh$)
  ref(chan, 1, 1) = VAL(LEFT$(startlow$, 7))
  ref(chan, 2, 1) = VAL(LEFT$(starthigh$, 7))
35 PRINT #1, ESC$;
  CALL RCV

.....GET READINGS OF 50 uL DISPENSES.....
FOR j = 0 TO ENDCNT
40 VIEW PRINT 4 TO 5
  IF j > 0 THEN
    CLS (2)
    IF (RMX OR BENCH) THEN PRINT " PRISM NOW DISPENSING"; ELSE PRINT "; "
    DISPENSE";
45 PRINT " 50 uL INTO CUPS " + chana$ + " AND " + chanb$;

IF (RMX OR BENCH) THEN PRINT " - PLEASE WAIT" ELSE PRINT " THEN WAIT FOR BEEP
WHILE READS STABILIZE"
PRINT " DISPENSE NUMBER "; j;

```

```

CALL DISPTRAY(chan)

VIEW PRINT 14 TO 23
5 LOCATE 23,1

rmxprime = 0

dispoff = -1
10
STEP 5
GOSUB DBLREAD

..... BENCH .....
15 IF BENCH THEN
    CALL BENCHDISP
    CALL BENCHDISP
    END IF
..... BENCH .....
20
GOSUB DBLREAD

..... BENCH .....
25 IF BENCH THEN
    CALL BENCHDISP
    CALL BENCHDISP
    END IF
..... BENCH .....
30 dispoff = 0

.....DISPLAY A,B CUP READS WHILE FILLING.....
'WHILE INKEY$ = ""
' GOSUB DBLREAD 'get a,b adc values
35 DIFFCNT = 0
'.....LOOK FOR DISPENSE
DO
GOSUB DBLREAD

40 .....RMX Parallel .....
IF RMX AND (rmxprime = 0) THEN
DO
CALL GETNEWKEY(NEWKEY$)
CALL getrmx
45 LOOP WHILE rmxrcv <> 2 'look for prime start
IF DEBUG THEN PRINT " Received PRISM Start Prime Command"
rmxprime = -1
END IF
.....RMX Parallel .....

```